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WILLIAM FAIRBAIRN, F.R.S.; WILLIAM CROOKES, F.R.S.;
ROBERT HUNT, F.R.S.; H. WOODWARD, F.G.S., F.Z.S.;

AND

JAMES SAMUELSON, EDITOR.

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I. THE ETHEREAL HYPOTHESIS OF LIGHT.

By JAMES SAMUELSON, Editor.

THE thirst for knowledge in the human mind is as insatiable as the wants of an immortal soul are necessarily unlimited. There are indeed myriads, content to go their daily rounds and confine their inquiries to the price of corn, cotton, consols, or whatever staple may serve to provide them with the necessaries and luxuries of life; but there are nobler men than those, who would rather be the discoverers of a secret in nature that yields wealth to thousands, than one of the ignorant thousands who reap the fruits of their researches; and of such men none have shown themselves more disinterestedly devoted to their intellectual calling than the students of physical and chemical science. Indeed it is almost to be regretted that they are not a little more worldly, for in that case their scientific theories and speculations would probably rest upon a more material basis than they sometimes do at present. Amongst the numerous subjects which are now engaging the attention of physical philosophers, there is none, perhaps, of deeper interest either to scientific men or to the lovers of the mysterious in nature, than that which relates to the illimitable space, wherein the universe of suns and planets moves incessantly, which serves as the medium to convey intelligence from sphere to sphere, and to communicate life from the great centres to the surrounding orbs. But it is rather as a curious inquirer, than with any pretensions to original research; rather in the hope that my observations and criticisms may stimulate discussion and cause further investigation, than with any expectation that they will throw fresh light upon so difficult and obscure a cosmical inquiry, that I propose its consideration in the present article.

There are in the present day two distinct theories in relation to light, arising not from any difference of opinion as to the action of

that force, inasmuch as the undulatory theory is now pretty generally accepted, but from opposing views as to the medium upon and through which it operates. It is needless for me to dwell long upon the undulatory theory, but, for the government of those who have not devoted much attention to the subject, it may be as well to mention that formerly light was not regarded as a force acting upon matter, but was supposed to consist of particles or atoms emitted by the luminous body, whilst electricity was considered an imponderable fluid which travelled through the substances electrified. Now, strangely enough, the views of the more advanced physical philosophers are to some extent reversed. Mr. Grove considers the electrical spark, at least, to consist generally of projected particles of the electrified substance,* and he gives apparently satisfactory reasons for so doing, whilst Professor Tyndall thinks that electricity may be a force acting upon "condensed ether which surrounds the atoms" of matter.† And on the other hand, as we shall presently find, the latter entirely discards the notion of any known substance as the vehicle of light, whilst Grove considers it to be a force acting upon gross but highly attenuated matter. But as I have already said, all are agreed upon the dynamical theory of light, first propounded by Huyghens in Newton's time, and afterwards supported and established in this country by Dr. Young; and this theory attributes to light a similar, though not exactly the same property, as sound, regarding it as a force which causes undulations of marvellous rapidity in the medium through which it travels. In the case of sound, the passage of the force is admitted on all hands to be through known matter, and it is well known that a vacuum is incapable of transmitting sound; but in that of light, which passes from sphere to sphere in the universe, and traverses a vacuum with apparently greater facility than air, it is obviously necessary either to discover or to suppose a medium for its transmission. That there is such a medium in interplanetary space is most probable, for light occupies *time* in its passage, corresponding with the distances between the luminous bodies from which it emanates and the spheres it illuminates, and therefore (in the case of our sun and earth for example) it cannot be the atmosphere alone which offers resistance to its passage. There is most likely matter of some kind, however attenuated, in space; and this is shown, not alone by the impeded passage of light, but by the retarded motions of the comets.

But what is that interplanetary matter?

* "The electric spark, the brush, and similar phenomena, the old theories regarded as actual emanations of the matter or fluid Electricity, I venture to regard them as produced by an emission of the material itself from whence they issue, and a molecular action of the gas, or intermedium, through or across which they are transmitted."--'Correlation of Physical Forces and Continuity,' p. 112. 5th edition. Longmans: see also p. 181.

† 'Heat as a Mode of Motion,' p. 216, note. 2nd edition. Longmans.

Is it, as Professor Tyndall supposes, a specific "ether," which serves as the vehicle for light and electricity? Does it enter, as he believes it does, into the constitution of material bodies? or is it excluded beyond the limits of our atmosphere? Or again, is it, as Mr. Grove believes, an attenuated gas or mixture of gases, given off from the atmospheres of the revolving worlds?

Let us first endeavour to understand the conceptions of these opposite thinkers, and then to test their respective hypotheses by the best means at our command. Professor Tyndall's conception of a "luminiferous ether" is that it is "a substance almost infinitely elastic," filling all space as with "jelly." * It fills up the interstices between molecules of all kinds of matter, "suffering no rupture of continuity at the surface of the eye, the intermolecular spaces of the various humours being filled with it."† He believes it to form the infinite ocean in which worlds move, and to be the medium for the transmission of light there, as well as in the intermolecular spaces of material substances—in short he regards it as the medium for the transmission of light—(and probably of electricity) *everywhere.*

Mr. Grove objects to this idea of a *specific* ether, both for the transmission of light and electricity.‡ His views concerning the latter force we have given generally,§ and his ground for refusing to accept the doctrine in regard to light is, that "the more porous bodies, or those most permeable by ether, *should be* the best conductors,"‖ and that "an objection immediately occurs in the opacity of porous, and transparency of certain dense bodies.¶ He believes in the universality of ordinary matter, however attenuated, and considers his hypothesis "the least gratuitous."**

There are other writers, who, seeking to reconcile these opposite views, suppose that the ether does *not* penetrate our atmosphere, being "non-miscible" with it, and that therefore it does not permeate terrestrial matter.††

This hypothesis may be at once dismissed, for if the supposed ether is not miscible with our atmosphere, then the latter should itself be the medium upon which light operates; therefore the first stroke of the piston of an air-pump should cause the receiver to darken, and an object in an exhausted receiver should be invisible, just as the sound of a bell striking therein is inaudible. In the present state of the discussion and of our knowledge, therefore, we are left to consider the respective merits of the two hypotheses,

* 'Heat as a Mode of Motion,' p. 254

† 'On Radiation,' p. 9. Longmans.

‡ 'Correlation and Continuity,' p. 133–4.

§ They will be found detailed in the chapter on "Electricity" in his work on the 'Correlation of the Physical Forces.'

‖ 'Correlation,' p. 148. ¶ Ibid., p. 168. ** Ibid., p. 186.

†† Brooke's edition of Golding Bird's 'Natural Philosophy.' Sixth edition, p. 576. Churchill.

which for convenience I shall call those of Grove and Tyndall;* and in order to guide the students of various branches of physical science in their investigations, I propose, first, to select a few phenomena for the consideration of the micro-zoologist, chemical and physical experimenter, and mineralogist, and then to point out what appears, in my humble judgment, to be the inference deducible from those phenomena, leaving it to each class of observers to consider the value and accuracy of my investigations, and of the conclusion to which I have been led by them.†

First, then, it is familiar to all who have any knowledge of natural history that the brilliant hues of the Lepidoptera, or Butterflies, are due to innumerable minute scales, regularly disposed upon their wings, just as the feathers of birds impart the bright colours to those races. In certain butterflies the wings have an iridescent, or metallic lustre (*Lycæna Adonis*, the Clifton Blue); in others it is dead and velvety (*Vanessa Io*, the Common Peacock); whilst in others again, both appearances are intermingled (*Polyommatos Phlæas*, the small copper). Now let us inquire to what cause this phenomenon is attributable.

We will take a specimen of *Lycæna Adonis*, the Clifton Blue, of which the blue is quite metallic, or satiny, if I may be allowed to coin the word, and on placing a few of the scales of this insect under the microscope and examining them by transmitted sunlight, that is, by light reflected from the mirror and transmitted through the scales to the eye, we shall find certain of them quite crystalline and transparent (see Plate, Fig. 1); others bright orange-red (Fig. 2); and others again dusky brown, almost approaching to black.

Now let us close off the light reflected from the mirror and examine the same scales by incident light, that is, by light concentrated upon them with the aid of the bull's-eye lens, and we shall find those which by transmitted light appeared translucent and colourless (Fig. 1) to be greenish brown or grey, studded with bright spots (Fig. 1a); those which were orange-red by transmitted light (Fig. 2) now appear of a brilliant violet-blue (Fig. 2a), the characteristic blue of the wings themselves; whilst the dull brown

* I call the "ethereal" theory Professor Tyndall's, inasmuch as he has sought to develop it; but those who are interested in its origin and history may refer to that author's work, 'Heat as a Mode of Motion.' Professor Faraday appears to have given a cautious, or perhaps I should say partial, adhesion to the theory; and he refers to it once or twice in passing, in the Bakerian Lecture of 1851, which I shall quote freely in this article. See also Tyndall's 'Faraday as a Discoverer,' p. 129. Longmans.

† Mr. Clerk Maxwell, it may be mentioned, considers "light" as a mode of electro-magnetic motion. He says, it "consists of alternate and opposite rapidly recurring transverse magnetic disturbances, accompanied with electric displacements, the direction of the electric displacement being at right angles to the magnetic disturbance, and both at right angles to the direction of the ray." (Proceedings of the Royal Society, 1864.)

scales (Fig. 3) are the least changed of any, being rather lighter (Fig. 3a) and presenting a steel-like surface.

The cause of these changes is quite obvious.

In the scale which was translucent and colourless by transmitted, but brownish-grey under incident light, a portion of the ray (as I shall for the present call it) is reflected back to the eye in the latter condition; that is to say, whilst it passes unimpeded through the scale in the first instance, it is arrested in the second, being partly absorbed and partly reflected. In the scale which appeared differently coloured under both aspects, namely, red by transmitted, and blue under incident light, the ray was arrested in both instances, the same part, namely, the orange-red passing through, and the other (the blue) being reflected. In the first instance, we saw the ray which had passed; in the second, that which was unable to pass, but which was reflected. (It must always be borne in mind that for the present I speak popularly, for we shall presently consider what "ray" and "portion of ray" really mean.) In the third example (3 and 3a) there is secreted in the scale itself a substance which has the power of arresting certain rays when the light enters from above (incident) less than when it strikes upwards from below (transmitted). Because, in the first instance, the scale surface arrests and reflects a portion of the light before even it enters the scale, as exemplified also in Fig. 2a, or perhaps more characteristically still in another species, *Lycæna Alexis*, where the scale is pale brown (also caused by pigment) by transmitted, and pearly opal (Fig. 5) under incident light. In the "Admiral" (*Vanessa Atalanta*) the effect is as nearly as possible the same under both conditions, the colour being due to pigment, Fig. 4.*

Deferring for a time the consideration of the bearing of these phenomena upon the ethereal hypothesis, I will now direct the reader's attention to the results of a few of the elaborate and interesting experiments of the late Professor Faraday, connected with "the relations of gold and other metals to light." These were fully recorded in his Bakerian Lecture, 1857, and printed in the 'Philosophical Transactions' for that year; and a careful perusal of his observations, and if possible a repetition of his experiments, will well repay the student for his labour. He found that gold-leaf

* In order to ensure accuracy as to the *cause* of the colour in these scales, I enlisted the aid of my friend Dr. Frankland, to whom I sent portions of the wings and scales corresponding with those which I had submitted to microscopical investigation. He bleached, or tried to bleach them with Peroxide of Hydrogen, and with Chlorine water, and the result was generally, as I had anticipated. The brown scales bleached easily and completely; the blue ones only turned pale green. After describing to me the different reactions, Dr. Frankland said:— "Judging from these experiments as well as from the appearance of the wings, I should say that the blue scales owe their colour in every case to interference, whilst all the rest are tinted with pigments."

by transmitted light is green; by incident light, yellow, and of a metallic lustre.

"When gold-leaf is laid upon glass, and its temperature raised considerably without disturbance, either by the blow-pipe or an ordinary argand-burner, it seems to disappear, *i. e.* the lustre passes away, the light transmitted is abundant and nearly white;"* but "when gold, rendered colourless by annealing, is subjected to pressure, it again becomes a green colour," . . . . and "the green colour can be again taken away by heat to appear again by renewed pressure."† Again, gold in a minutely divided condition caused by deflagration, *transmitted* violet, green, or ruby rays; but by *reflected* light "it is golden and metallic."‡ "It is evident that all the colours described are produced by one and the same substance, namely, gold, the only apparent difference being *the state of division* and different degrees of the application of heat;"§ . . . "and I think I am justified by my experiments in stating that fine gold particles so loosely deposited that they wipe off by a light touch of the finger, and possessing one conjoint structure, can in one state transmit light of a blue-grey colour, or can by heat be made to transmit light of a ruby colour, or can by pressure from either of these former states transmit light of a green colour, all these modifications being due to gold as gold."‖ That it is the disposition of the particles which causes the modifications of colour is further shown by the author, when he says¶ that thin films of gold prepared by phosphorus give "a feeble grey-violet" by transmitted light; if the films are a little thicker they give "a violet;" but "superposition of several grey-violet films does not produce a green tint, but only a diminution of light without change of colour." Yet it will be remembered that a sheet of gold-leaf gives a bright green.

Another result of Faraday's observations is that vapours and gases will pass through these films;** and their appearance with a power of 700 linear is reported to be "slightly granular."††

* 'Phil. Trans., 1857,' p. 148.

† Ibid., p. 149. It may be as well to mention here what Faraday thought in relation to the cause of the change. At p. 149 he says:—"As to the essential cause of this change of colour, more investigation is required to decide what that may be. As already mentioned, it might be thought that the gold-leaf had run up into separate particles. . . . On the whole I incline to this opinion." Let me add in reference to these remarks of Faraday, that on examining with a microscope some "gold bronze," which I know consisted of very fine particles of gold, I found that by transmitted light they gave in the mass a yellowish-red colour, and each particle precisely resembled minute flakes of crumpled gold-leaf; but when I subjected the dust to pressure between two sides, not alone each particle, but the whole aggregation of them assumed the characteristic green hue—the change being, however, more apparent in the individual particles.

‡ Ibid., p. 152. § Ibid., p. 153. ‖ P. 153. ¶ Pp. 155–6.

** "Experimentally, also, I find that vapours and gases can pass through them," p. 156.

†† P. 157.

After reading the account of Faraday's beautiful and exhaustive experiments,* of which I have only referred to one series, I should have despaired of being able to add any information that would elucidate our inquiry had not nature herself prepared a beautiful microscopical object, which, in common with many friends, I have examined with undiminished pleasure and admiration for nearly twelve years.

It is called the "Sonnenstein," or Sun Stone, from its peculiar brilliancy, and is found in Arendal in Norway. Its brightness is due to innumerable minute metallic crystals imbedded in a matrix of a translucent substance of a spar-like nature. Examined with a low power by transmitted light, it resembles a colourless transparent fragment of glass or spar, containing irregularly-shaped pale, orange, and red translucent crystals (Fig. 6); where these are superposed one above another, they assume a brighter hue; but when viewed by incident light an almost miraculous transformation takes place, some of the crystals appearing bright blue, others presenting every colour of the spectrum, and if the object be turned slowly round the same crystals reflect different hues as they revolve.† The transparency of the matrix is due to its extreme tenuity (the object having been cut with the aid of a mechanical contrivance, by the late Dr. Oschatz of Berlin), and viewed with a higher power under incident light in one position, the light is reflected from its

* I have also considered those of Professor Tyndall, just published in the 'Proceedings of the Royal Society,' and fully reported in our Chronicle of Physics; but although they are very interesting, I do not at present see anything in them to throw fresh light on our inquiry.

† My correspondent, Mr. T. Rudler, of the Museum of Practical Geology, gives me the following account of the "Sonnenstein."

"The mineral called by the Germans '*Sonnenstein*,' by the French '*Pierre de Soleil*,' and by the English '*Sun-stone*,' is a variety of Oligoclase-felspar, originally discovered at Archangel, but now found chiefly in Norway. It exhibits a beautiful spangled appearance, somewhat resembling that of Aventurine, and hence it has been called Aventurine-felspar. This appearance is apparently due to the reflection of light from the walls of minute fissures traversing the stone, and also to the presence of small six-sided plates which are usually disseminated through the mineral. What they really are, is difficult to say. Scheerer regarded them as crystals of specular Iron Ore (anhydrous Peroxide of Iron), and Oschatz confirmed this observation, but Kenngott will have it that they are magnetic pyrites Pyrrhotine). Some, I believe, regard them as titaniferous iron ore, whilst others refer them to the species Göthite. Formerly they were thought to be little scales of Mica.

"I ought, perhaps, to say there is some little confusion in the use of the word 'Sun-stone,' as a few writers have applied it to an opalescent potash-felspar, or Adularia. The beautiful colours exhibited under the microscope by the embedded crystals are due, I should think, rather to their extreme thinness than to any colour inherent in the crystals."

To this account of Mr. Rudler, I would add that from the analogy between them and the iridescent butterfly scales (Figs. 2 and 2a in my Plate) which are red by transmitted, and blue by incident light, I have no doubt that their brilliant colours are due to reflexion from their surface. In my specimen there are scales which are opaque by transmitted light and which *more nearly resemble a crumpled fragment of metallic tinsel than a flat geometrical crystal*; indeed the crystals are very irregular and not often six-sided.

surface, which is then opaline (Fig. 6a), and the imbedded metallic crystals are invisible. As to the dimensions of my little preparation, it is difficult to form a correct idea of them. In the Plate (Fig. 6 and 6a) the whole object is magnified about 5 diameters, or about 25 times in superficial area: but from the mode in which it is mounted between sheets of glass above and below (the former being a combination of two slips, flint and crown, I believe), it is impossible to form an accurate estimate of its thickness. In conjunction *with a friend, an experienced microscopical* observer, I have, however, tried to form an approximate idea, and with a magnifying power of 56 diameters, it appears about $\frac{1}{32}$ of an inch thick, therefore in reality it may be from $\frac{1}{1800}$ to $\frac{1}{1000}$ of an inch. This is a very rude mode of arriving at its thickness, but it would be quite useless even to guess at the degree of tenuity of the contained crystals or plates. They are embedded at various depths in this thin shaving of mineral, showing no indications of an edge, and are sometimes at such relative distances below each other, that the focus requires to be considerably changed to bring one after the other into full view. Occasionally they are superposed one above another with a space intervening. I have examined some of the individual crystals with powers of 200, 270, 540, 900, and about 1300 diameters, and notwithstanding their extreme tenuity, I have not been able to detect the least appearance of structure, or breach of continuity in the uniformly flat orange-yellow surface which they present to the eye by transmitted light. Where a crystal happens to be imperfect, its broken edge examined with a high power, resembles torn paper, but has no indication of geometrical symmetry.

As already stated, these crystals, which by transmitted light are a uniform orange, by incident light *reflect* all the colours of the spectrum, each crystal reflecting usually one colour, but often the same is variously tinted. In Fig. 7 I have attempted to represent a few of them, but no idea can be formed of their brilliancy unless they are seen under a good bright light in nature. Sometimes (as in the three upper crystals in the figure) the same crystal reflects a metallic lustre in one position, and exhibits the orange transparency in another. Sometimes again, a sharp line divides a crystal in two, and if it be moved round, each division will, by turns, present the transparent orange and the reflected light. This is doubtless owing to the light being reflected from some neighbouring crystal or from one of the fissures of the felspar, and passing upwards through the whole or part of the crystal, as in the case where transmitted light is used.

The matrix of felspar partially depolarizes polarized light, but the latter has not the least effect upon the imbedded crystals.

Before considering the bearing of these phenomena upon our inquiry, let us briefly refer to another, in which the experimenter calls into action the force of which he at the same time observes the

effect upon matter. It will be found described in Professor Tyndall's 'Radiation,'* already quoted, and is one for which we are indebted to the researches of Dr. Draper. By means of a current of electricity, a platinum wire is gradually raised to a state of incandescence, and after the luminous rays emitted by the wire have passed through a prism, the prismatic colours appear one by one as the light becomes more intense, beginning at the red, and ending at the violet end of the spectrum, until from a white light in the wire the whole of the spectrum is obtained upon the screen.

And now, before we endeavour to glean from these phenomena what information we are able concerning the action of light, let us try to define what "light" means. Of course, according to the "ethereal hypothesis," it is the vibrations of the atoms of the hypothetical "ether;" but if we adopted this definition we should be admitting the hypothesis of which we desire to test the accuracy, and should be reasoning from the unknown to the known: this we must of course avoid.

All observers will agree in regarding light as a *force* operating upon and causing a motion of matter. It proceeds in a right line and passes freely, and probably unchanged except in degree of intensity, through air, through what *we call* a vacuum, and, when it falls upon them at certain angles, through other forms of matter which are known as transparent; but it is also a force, capable when it reaches some forms of matter, (by what means we cannot say), of resolving itself into three or more distinct modes of action, differing in their nature and operation. Sometimes one of these modifications of the force is incapable of producing any perceptible effect upon a particular form of matter, and then it reflects back upon and through the same unknown medium until it reaches the retina, where it produces the effect known as *colour*. At other times some portion of the force is inoperative when it reaches the surface of the material object, and then its reaction or reflexion causes a combination of colours. In other cases again, chiefly when the force reaches certain forms of matter at a particular angle, no portion of the force is able to affect it, and then we have what is called the reflexion of ordinary light, but there are cases where the whole force is capable of acting upon and through the same form of matter, but whereas it entered it as one whole force, it issues from it as three or more distinct forces or phases of force, and those forces, when they again reach certain forms of matter, reflect upon the retina as a complete "spectrum."

Of all these effects of the force "light" we have had examples in the phenomena already referred to, and in some of them, as for example in the sunstone, we had, in the same object, illustrations of nearly all the modifications to which the original force is subject,

* 'Radiation,' pp. 2, 3.

and of its resolution as above stated. And now let us inquire whether and in what manner light differs in its operation from the other known forces, or "modes of motion." First, as regards its penetrability. If we do *not* assume that the medium which serves as its vehicle until it reaches a solid object enters into the constitution of that object, but that it is arrested at its surface, then we shall find that the *impact* produces the same effects in the case of light as in other forces, and, moreover, we shall avoid a grave difficulty attending the assumption that the hypothetical "ether" serves as the vehicle of light in and through the solid body, namely, that porous substances through which the "ether" should pass most freely are opaque, whilst dense forms of the identical substance are transparent.

If we place a number of billiard-balls in a row thus (Fig. 1),

Fig. 1.

Fig. 2.

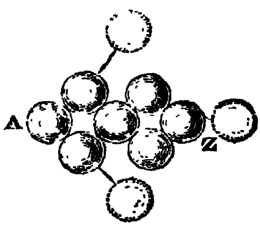
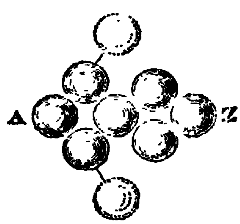


Fig. 3.



and drive a ball or other object against the terminal ball A, the force traverses the whole closely-packed series instantaneously, and the ball Z starts forward at once;* but if the balls are disposed as at Fig. 2, and A be struck with the same force, Z will only move slightly forward, and not so instantaneously as before; and if they be disposed as at Fig. 3, not touching each other, then if A be struck, Z will not move at all, but some of the intervening balls will fly off laterally at different angles. Now the first position (Fig. 1) may be assumed to be that of the particles of matter in a *dense*, and the other two in porous bodies, and if we regard light as a "mode of motion," there is nothing abnormal in its passing more rapidly through, or, to speak correctly, in its traversing the particles of a dense than a porous body, merely on account of the density, and provided the particles be conveniently disposed. Again, air is the medium of *sound*, as ether is supposed to be that of light; but when sound, or rather the agitated air,† impinges upon the

* Professor Tyndall employs this illustration to exhibit the effect of sound.

† Perhaps it would be more correct to say that sound is the vibration of the sensible, as heat and light are the vibrations of the insensible parts of an object. The latter definition is Locke's.

sonorous object, the air does not enter into the object, but the force is transferred to the material particles of the object itself. Blow into the air and you have no sound (except that caused by the compression of the air between the lips). The air is transparent or nearly so, to sound. Blow upon a tumbler, and you have a "note." There is a reflection or reaction of part of the force upon the air, and an absorption of the other into the sonorous substance; and, precisely as in the case of light, the effect produced is varied according to the nature of the object upon which the force impinges. Professor Tyndall has shown the close analogies between sound and light in his beautiful work on the former force;* but I cannot help thinking that if he had considered the nature of the "chromatic" scale in both cases, conjointly with the other resemblances between the two forces, his views regarding a hypothetical ether *circulating within bodies*, would have become modified. He attributes the velocity of sound in its passage through substances, to a direct action upon the matter itself; but why not suppose some attenuated gas to be the medium, as sonorous "ether?" Such a supposition is at once negatived by the fact that whilst the velocity of sound through the rarest of gases is only 4164 feet in a second,† it traverses steel wire at the rate of 16,023 feet per second. The density of a substance does not therefore necessarily impede the passage of *sound* (any more than that of mechanical *motion*), and when the field of operation of the force is changed, and it leaves a rarer form of matter to act upon a denser one, its effect in the new direction is intensified and its result upon the senses changed.

So far, then, as the analogies between light and sound, as well as the mere density of bodies, are concerned, we are at least as correct in leaving the "ether" (whatever that may be) at the outside, as in admitting its presence within solid bodies; and now let us inquire how various substances behave under the influence of light as compared with other forces, which are supposed by the etherealists to have the ether for their vehicle *everywhere*, within as well as without solid objects.

The following are the conducting or transmitting powers of certain well-known types of matter:—

	Heat.	Light.	Electricity.
Metals	good	bad	good.
Charcoal	fair	bad	good.
Ice	bad	good	fair.
Porcelain	bad	fair	bad.
Glass	bad	good	bad.
Rock Salt ..	bad	good	bad.

Now, when we consider these phenomena along with those referred

* 'On Sound,' p. 44. Longmans. † Ibid., p. 37.

to in our illustrations, we must be struck with the insufficiency of the "ethereal" hypothesis to afford an explanation of them. On the contrary, I fear the remark of Dr. Frankland,* which I apprehend he meant to be applied to this hypothesis, holds good, that "it hinders rather than expedites the advance of the experimenter." Suppose we were to assume that the "ether suffers no rupture of continuity" at the surface of glass, for instance;† how is it that the force, "light," acting upon that "ether," passes through the glass freely, whilst one of its resolved forces or phases, heat, notwithstanding that it operates solely upon the same hypothetical medium, is unable to pass? It cannot be merely because "light" proper acts upon the ether with greater intensity, causing it to vibrate more rapidly than heat; for, according to Professor Tyndall, that would result in the mere phenomena of light and darkness. "Darkness," he says, "may be defined as ether at rest; light as ether in motion:"‡ and although the same author says the ether never is at rest, and that when light-waves are not passing through it, heat-waves are; yet I do not see how the two forces can be severed, and more especially how one can be reflected (or, more strictly speaking, can reflect) back, whilst the other proceeds onwards, as we found it to do in our insect scales and in the other cases described, unless the medium which yields to one phase of the force, and resists the passage of the other, is different from that which serves as the vehicle of the reflected force, or is invested with the attributes of various kinds of gross matter; and, indeed, it appears to me that there must be either a distinct form of "ether" for each force, or *one phase of the force must act directly* upon the constituent particles of the object which is transparent to it, and the other react upon the medium which served as its vehicle until it reached the surface of the solid object. Nor can we suppose "ether" to be invested with attributes which cause it to change the character of the force with the direction of its passage through it; for although the *velocity* of heat travelling through certain crystals is greater in one direction than in another,§ and along the fibre of wood greater than across it;‖ yet it always remains "heat," a force which is supposed by the etherealists to consist, like light, of the "vibration of ether" *everywhere,* so in whichever way we try to use the "ether," we always find that it is the particles of matter which, after all, modify the force.

There is another circumstance which I should like to submit for the consideration of those who are desirous of forming accurate

* 'Proceedings of Royal Institution,' June 12, 1868.
† I have taken glass as a familiar example, but rock-salt is a better one.
‡ 'Radiation,' p. 9.
§ 'Heat as a Mode of Motion,' p. 221.
‖ Ibid., p. 223.

conclusions on this interesting subject. There is no reason why the form of matter which is believed to serve as the vehicle of light should be so extremely attenuated as the "ether" is supposed to be, except the necessity which seems to exist in the minds of the etherealists of its permeating all other matter; but when we look at the known attenuated forms of matter, we find that even the most highly rarefied are unable to penetrate certain dense substances, and pass through porous ones slowly. Professor Faraday found that the materials upon which he operated were pervious to the passage of gases and vapours, but what must be the nature of that "ether," through which the light waves are supposed to speed, undergoing transformations in their passage, and which must be continuous in its presence through the various dense substances composing "Sonnenstein." First, it must pass through a thickness of glass and through felspar, in both of which it must serve as the vehicle of colourless light; then it must be agitated within an embedded crystal, or if there be two superposed, then through both and the intervening felspar, and in all three it must serve as the medium for the force which subsequently becomes apparent to the sense as orange light; then another layer of felspar intervenes; next, flint and crown glass; and then it passes through air, a form of matter in which the hypothetical ether may be supposed to agitate freely. But here its course is not ended; lens after lens of the microscope, each with its particles closely packed, and humour after humour of the eye must all be filled with this attenuated "ether," and must afford space for and be accommodated to instantaneous changes in its varied vibrations.

I have no wish to dogmatize upon this difficult theme, my purpose being, as stated at the outset, to present a few phenomena for the consideration of the reader, and to suggest such inquiries as seem to me calculated to throw light on the subject. From the foregoing remarks, however, it will be clear that I lean to Grove's view of the purely material character of the substances which serve as the vehicles of light, and that, notwithstanding the need which appears to exist for some special medium, either elementary or compound, to provide for its passage across a "vacuum," yet I cannot admit either the possibility or necessity for a *specific* "ether" which permeates all matter. For although the chain of hypotheses which must be employed to support the one hypothesis of a homogeneous specific "ether," filling all space and "fitted mechanically for the transmission of the vibrations of light and heat,"* and permeating all kinds of gross matter, may seem necessary and justifiable in the minds of those who are more accustomed than I am to consider these phenomena, yet it seems to me that before the hypo-

* Tyndall's 'Radiation,' p. 8.

thesis becomes a theory it will be necessary to invest the "ether" with the properties of a variety of forms of known matter, in addition to some abnormal attributes which it is already supposed to possess, and such a proceeding appears less philosophical than to seek in the phenomena connected with known forms of matter, a revelation of the nature and *modus operandi* of "light" and its constituent forces; or failing that, to wait patiently for the discovery of new material conditions that may render the problem less difficult of solution.*

DESCRIPTION OF THE PLATE.

FIG. 1.—Battledore scale of *Lycæna Adonis* (Clifton Blue Butterfly), viewed by transmitted light, magnified 250 diameters.
„ 1*a*.—The same, viewed by incident light, magnified 250 diameters.
„ 2.—Another scale of *Lycæna Adonis*, viewed by transmitted light, magnified 150 diameters.
„ 2*a*.—The same, viewed by incident light, magnified 150 diameters. Colour probably due to structural arrangement of particles.
„ 3.—Another scale of the same, viewed by transmitted light, magnified 150 diameters.
„ 3*a*.—Scale of the same, viewed by incident light, magnified 150 diameters. Colour due to pigment.
FIG. 4.—Scale of *Vanessa Atalanta* (The Admiral), magnified 150 diameters. Colour due to pigment.
„ 5.—Scale of *Lycæna Alexis* (the Common Blue), magnified 150 diameters.
„ 6.—"Sonnenstein." by transmitted light, magnified 5 diameters.
„ 6*a*.—The same, by incident light, magnified 5 diameters.
„ 7.—Crystals embedded in "Sonnenstein," viewed by incident light, magnified 75 diameters. (The three upper objects in Fig. 7 are the same *crystal in different positions, but always illuminated by incident light.)*

II. THE ALKALINE LAKES OF CALIFORNIA.

By J. ARTHUR PHILLIPS.

ALKALINE and thermal springs abound over an area constituting a large proportion of the State of California; whilst in some extensive districts, and particularly in the vicinity of the great Colorado desert, the ground during the dry season is whitened by an incrustation principally consisting of various salts of soda.

In many parts of the country also, although alkaline springs are readily found, potable water is exceedingly scarce, being usually met with but once or twice only in the course of a day's journey.

* It is only fair to Professor Tyndall, that after availing myself so largely of his writings, I should mention that his views and speculations on the subject of the "ether," which I need hardly say are well deserving of consideration, will be found in the work just quoted, as well as in his 'Faraday as a Discoverer.'

James Samuelson ad nat. del[t] M & N Hanhart, Chromo lith

MICROSCOPICAL OBJECTS TO ILLUSTRATE THE ARTICLE ON ETHEREAL HYPOTHESIS OF LIGHT

The most remarkable accumulations of alkaline waters are, however, those of Mono Lake and Owen's Lake; and of these, together with the celebrated Borax Lake, I propose giving a short description.

Mono Lake.—Mono Lake is about fourteen miles long from east to west, and, in its broadest portion, nine miles wide from north to south; it was, however, formerly much larger than it now is, its ancient shore-lines being very conspicuously indicated by a succession of parallel terraces.

On its south-eastern side a ravine has been eroded through the sandy desert which surrounds it, to a depth of from sixty to a hundred feet; and in this cañon five well-defined terraces may be distinctly seen. The level of the lake was once certainly at least 600 feet higher than it now is; and it is not improbable that it then communicated with the valleys both of the Carson and Humboldt, thus forming a most important feature in the ancient geography of the country.

The waters of this lake, which have a high specific gravity, are intensely alkaline and saline, removing grease readily, and being far more detergent in their properties than ordinary soap-suds.

They contain, in addition to common salt, large quantities of carbonate and sulphate of soda, and apparently also a certain proportion of lime, since large quantities of calcareous tufa have been deposited along the lake-shore, and on the terraces far above the present level of its waters. Near its northern shore are numerous springs holding much lime in solution; these have caused the formation of extensive deposits of tufa, some of which rise above the surface of the lake, resembling gigantic fungi of from six to ten feet in height.

In Mono Lake there are several islands, two of which are of considerable size,—the larger being two-and-half miles in length, whilst the smaller is about half-a-mile long. To the north of this lies a group of volcanic islets of inconsiderable dimensions. On the south-eastern corner of the larger island are numerous hot springs accompanied by jets of steam, covering some thirty acres of land, and extending into the lake itself, thus perceptibly raising its temperature for a considerable distance.

The steam and heated gases thus escaping at the same time from hundreds of fumeroles, are often attended with considerable noise, and deposit around the orifices of many of the apertures a red incrustation, probably of chloride of iron: there is, however, no smell of sulphur, nor any deposit of that substance. On the north side of the island are two well-defined craters in the midst of hard basaltic rock, but both are now filled with water.

The smaller island is entirely composed of hard, dark basalt; and has at its western extremity a somewhat elevated volcanic cone of black basalt capped by cinders.

Myriads of aquatic birds resort during the breeding season to this lake; but its waters are, with the exception of the larva of a fly, destitute of life. These larvæ, which are small white worms, occur in such immense quantities, that they are collected by the Indians, under the name of "Koo-chah-bee," as an important article of food. For this purpose they are first dried in the sun; the hard cuticle is then crushed by rubbing between the hands, and afterwards separated by winnowing in large shallow baskets. Before being eaten, the prepared grubs are kneaded into a kind of dough, and baked in the embers.

Stretching south from Mono Lake is a chain of extinct volcanoes: obsidian and pumice are abundant throughout the whole region, the soil being so intensely dry and pulverulent, that the traveller sinks over his ankles at every step, and experiences no small difficulty in obtaining even a scanty supply of fresh water.

Owen's Lake.—This lake is situated about a hundred miles to the south-east of the foregoing, in lat. 36° 20′ S., long. 118° W. from Greenwich, and is twenty-two miles in length, and about eight in width. Owen's River rises in the Sierra Nevada, not far from the head of the San Joaquin, and near the southern extremity of the valley flows into Owen's Lake, which has no visible outlet, and whose shores are thickly coated by an alkaline incrustation. No fish of any description are found in its waters, but they produce large quantities of *koo-chah-bee,* which is plentifully collected by the various tribes of Indians inhabiting its shores, and dried for winter consumption.

The water of this lake has a specific gravity of 1·076, and contains 7128·24 grs. of solid matter to the imperial gallon; of this, 2942 grs. are chloride of sodium, 956 grs. sulphate of soda, and 2914 grs. carbonate of soda. The remainder consists of sulphate and phosphate of potash, silica, and traces of organic matter. Iodine is also present in very minute proportions.

The incrustations which at certain seasons of the year are deposited on its shores to the extent of many hundreds of tons, consist of a yellowish-white efflorescence. A specimen of this substance subjected to analysis afforded the following results:—

Chloride of Sodium	2·14
Sulphate of Soda	3·10
Carbonate „	46·10
Silica	0·22
Potash	traces
Water with traces of organic matter ..	48·44
	100·00

The carbonic acid and soda in this case exist in such proportions as to form a monocarbonate of that base; but fragments

collected from various other localities along the lake-shore showed a distinct excess of carbonic acid.

Twenty miles south of Owen's Lake is Little Lake, a pond evidently occupying the crater of an extinct volcano, and in the vicinity of which are some remarkable boiling springs. The country between Little Lake and Owen's Lake is a barren sandy plain, in which the only vegetation consists of a few cactuses, together with some stunted wild-sage bushes and grease-wood; whilst the surface of the ground is everywhere thickly strewn with fragments of obsidian, pumice, and tufa. These, with numerous extinct craters seen in the distance, sufficiently indicate the volcanic nature of the whole region.

Borax Lake.—This sheet of water, the Lake "Kaysa" of the Indians, is situated in Lake County, 110 miles from San Francisco, and lies a little east of Clear Lake, about half-way between Cache Creek and Hawkin's Arm.

This lake, which is separated from Clear Lake by a low range of hills belonging to the cretaceous period, has, under ordinary circumstances, a length of about a mile and an average width of half-a-mile. Its extent, however, varies considerably at different periods of the year, since its waters cover a larger area in spring than during the autumnal months. No stream of any kind flows into the basin, which derives its supply of water from the drainage of the surrounding hills, as well as, in all probability, from subterraneous springs discharging themselves into the bottom of the lake. In ordinary seasons the depth thus varies from 5 feet in the month of April, to 2 feet at the end of October.

Borax occurs in the form of crystals of various dimensions embedded in the mud of the bottom, which is of an exceedingly unctuous character, and is found to be most productive to a depth of about 3½ feet, although a bore-hole, which was sunk near its centre to a depth of 60 feet, afforded a certain proportion of that salt throughout its whole extent.

The crystals thus occurring are most abundant near the centre of the lake, and this rich portion extends over an area equivalent to about one-third of its surface. They are, however, also met with in smaller quantities in the muddy deposit of the other portions of the basin, some of them being, in the richest part before alluded to, over a pound in weight. The largest crystals are generally enclosed in a stiff blue clay, at a depth of between 3 and 4 feet, and a short distance above them is a nearly pure stratum of smaller ones, some 2½ inches in thickness, in addition to which crystals of various sizes are disseminated throughout the muddy deposit of which the bottom consists.

Besides the borax thus found in a crystalline form, the mud is itself highly charged with that salt, and according to Oxland, when

dried, affords (including the enclosed crystals) 17·73 per cent. Another sample, analyzed by Mr. Moore of San Francisco, afforded him 18·86 per cent. of crystallized borax.

In addition to this the deposit at the bottom of the other portions of the basin, although less productive, still contains a large amount of borax, and it has been ascertained by sinking numerous pits on the lake shore, that clay containing a certain proportion of this salt exists in all the low ground around it.

The borax at present manufactured is exclusively prepared from the native crystals of crude salt, whilst the mud in which they are found is returned to the lake, after the mechanical separation of the crystals by washing. The extraction of mud from the bottom is effected by the aid of sheet-iron coffer-dams, and dredging-machines worked by manual power, the whole of the labourers being Chinese. Until 1866 the only apparatus employed consisted of a raft covered by a shingled roof, with an aperture in its centre, about 15 feet square, and above which were hung, by suitable tackle, four iron coffer-dams each 6 feet square and 9 feet in depth. This raft or barge was moved in parallel lines across the surface of the lake, and at each station the four dams were sunk simultaneously by their own weight into the mud forming the bottom. When they had thus become well embedded, the water was baled out, and the mud removed in buckets to large rectangular washing-vats, into which a continuous stream of water was introduced from the lake by means of Chinese pumps, the contents of the cisterns being at the same time constantly agitated by rakes.

At the present time dredging-machines are employed for bringing up the mud and crystals from the bottom of the lake, and these are introduced into cisterns and washed as above described. In this way the turbid water continually flows off, and a certain amount of crystallized borax is finally collected in the bottom of each tank. This is subsequently re-crystallized, but from the density acquired by the washing water, of which some hundred thousand gallons are daily employed, it is evident that less than one-half the borax existing in the form of crystals is thus obtained, whilst that present in the mud itself is again returned to the lake.

In 1866, when I visited this locality, the crystals of crude borax daily obtained amounted to about 3000 lbs., and after being carefully washed, they were dissolved in boiling water and re-crystallized in large lead-lined vessels, from which the crystallized borax was removed into boxes each containing a hundred-weight.

The amount of refined salt daily obtained varied from 2500 to 2600 lbs., which was produced, as nearly as I could calculate, at a cost of about 18*l*. per ton.

It is evident from the foregoing description that the system of working employed is exceedingly crude, and by no means calculated

for obtaining the best results, and that in order to do so, it would be necessary to adopt some efficient process for the lixiviation of the mud after its removal from the bottom of the lake, and the re-crystallization of the borax thus obtained.

The total extent of the muddy deposit considerably exceeds 300 acres, and if we assume that of this area 100 acres, or that portion only now worked for borax crystals, would be sufficiently rich to pay the expenses of treatment by the process at present employed, we shall arrive at the following figures:—

One hundred acres are equivalent to 484,000 square yards, and if the mud were worked only to a depth of 3½ feet, this would represent about 565,000 cubic yards, or, allowing a cubic yard to weigh a ton, which is a very low estimate, the total weight of 100 acres of mud, in its wet state, will be approximately 565,000 tons. If the mud, as extracted from the lake, be now assumed to contain sixty per cent. of water, there will remain 226,000 tons of dry mud, containing, according to the mean of the analyses of Messrs. Oxland and Moore, 18·29 per cent. of borax, but if in practice only twelve per cent. of borax were obtained, this area alone would afford 27,120 tons of crystallized salt.

According to Mr. S. M'Adam, of Edinburgh, to whom a specimen was forwarded for analysis, the crude borax from Borax Lake has the following composition:—

Biborate of Soda, dry	51·85
Water of Crystallization	45·44
Insoluble matter	1·42
Sulphate of Soda, dry	0·06
Chloride of Sodium, dry	0·08
Phosphate of Soda, dry	1·15
	100·00

Mr. Moore, of San Francisco, gives the following as the composition of the water of Borax Lake, which has a mean specific gravity of 1·0274:—

In an Imperial Gallon.

Chloride of Sodium	1198·66
„ Potassium	9·92
Iodide of Magnesium	·22
Bromide „	trace
Bicarbonate of Magnesia	„
„ Soda	188·28
„ Ammonia	trace
Carbonate of Soda	578·65
Biborate „	281·48
Phosphate of alumina	3·52
Sulphate of Lime	trace
Silicic acid	2·37
Matters volatile at a red heat	238·66
	2501·76

In the foregoing analysis all the salts have been calculated as being anhydrous; but crystallized borax contains about 47 per cent. of water, and hence the 281·48 grains found will correspond to 535·08 grains of crystallized salt. Besides the amount of biborate of soda contained in the mud of the lake, its waters are therefore capable of affording at least 6000 additional tons.

The borax, being the least soluble salt present in any considerable quantity, has evidently been deposited in the form of crystals in the mud at the bottom; and that the process is still rapidly going on is shown by the coating of crystals formed upon sticks or other substances immersed for a short time in the waters of the lake. A consideration of the phenomena attending the production of borax further leads to the belief that its formation is effected by the decomposition of carbonate of soda by boracic acid emitted from sources beneath its bed, and large quantities of carbonic acid constantly escape from the surface of the water. Should this be the case, it is more than probable that any moderate extraction of borax will be fully compensated for by the formation of that salt constantly taking place.

The waters of another lake situated in a little valley a few miles north-east of Clear Lake, and surrounded by a thick forest of oak and pine, are also known to contain borax. The bottom of this lake, which covers an area of about twenty acres, consists of a clay similar to that found in the larger one; but although it contains large quantities of borax in solution, no crystals of that salt have as yet been found in the mud. In addition to the localities already mentioned, there are numerous springs in the vicinity of the lakes, the waters of which are more or less impregnated with borax.

To the north-east of Borax Lake, and about a mile from it on the borders of Clear Lake, is a large deposit of sulphur where solfatara action is still apparent. The volcanic rocks have here been extensively fissured and decomposed, and from the various orifices steam and sulphurous vapours are constantly issuing. The amount of sulphur which has been deposited in this place is very large, covering an area of several acres, but the depth to which it may extend can only be ascertained by the further development of the excavations now in progress.

From six to eight tons of this sulphur are refined daily by distillation in large iron retorts, after which it is used for the manufacture of sulphuric acid, and in gunpowder, match, and other factories. The most interesting fact in connection with this deposit is the association of cinnabar with the sulphur sometimes distinctly separated from it, in quartz, evidently of recent origin and deposited from solution, but more frequently thoroughly intermixed with the mass.

Another large deposit of sulphur, about two miles distant, occurs in what is known as Chalk Mountain, so called on account of its peculiar white appearance, caused by the decomposition of the volcanic rock; and still another at Sulphur Springs, farther east on the road to Colusa: but in neither of these localities is the sulphur discoloured by the presence of cinnabar. The rocks at Chalk Mountain are extensively fissured and much decomposed by the action of steam and acid vapours, and springs yielding water highly charged with carbonic acid are numerous throughout the district. In fact, volcanic materials and hot springs occur in a line from Clear Lake eastward toward the Sacramento valley, and, as Professor Whitney remarks, there is evidence of a transverse fissure extending from the Geysers across the volcanic belt, of which Mount St. Helena is the culminating point, to the Sacramento valley.

III. EXPERIMENTAL RESEARCHES ON THE MECHANICAL PROPERTIES OF STEEL.

By Wm. Fairbairn, LL.D., F.R.S., &c.

The present may be justly considered the age of iron, as in every branch of industry where force, form, and motion are required, iron enters largely into construction, and its powers of application have supplanted almost every other material. It presents wonderful facilities in its adaptation to every description of art, whether of the useful or decorative style; and its improved tenacity, elasticity, and ductility have enlarged its field of usefulness in the construction of buildings, ships, steam-engines, bridges, and machinery of all sorts where strength combined with lightness is required. To this powerful and valuable material we are indebted for railways, locomotives, and rolling stock; and there is no branch of manufacture in which it does not form a whole or a prominent part. Possessed of such a material in its cheapest and best forms, we should be deficient in duty if we left it in the rude state in which it was found in the days of Cort, and his immediate successors. That great improvements have been effected of late years does not admit of doubt, and there is probably no material that has undergone greater changes in its manufacture than iron; and judging from the attempts that are now making, and have been made, to improve its quality and to enlarge its sphere of application, we may reasonably conclude that it is destined to attain still greater advances in its chemical and mechanical properties. The earliest improvements in the process of the manufacture of iron may be attributed to Cort, who intro-

duced the process of boiling and puddling in the reverberatory furnace, and those of more recent date to Bessemer, who first used a separate vessel for the reduction of the metals, and thus effected more important changes in the manufacture of iron and steel than had been introduced at any former period in metallurgic history. To the latter system we owe most of the improvements that have taken place; for by the comparatively new and interesting process of burning out the carbon in a separate vessel, almost every description of steel and refined iron may be produced. The same results may be obtained by the puddling-furnace, but not to the same extent, since the artificial blast of the Bessemer principle acts with much greater force in depriving the metal of its carbon, and in reducing it to the state of refined iron. By this new process increased facilities are afforded for attaining new combinations, by the introduction of measured quantities of carbon into the converting vessel, and this may be so regulated as to form steel or iron of the homogeneous state, of any known quality.

The production of iron and steel in the homogeneous state is one of the most important improvements that have taken place since the process of rolling direct from the reverberatory furnace. The former process was first to melt the iron as it came from the smelting-furnace in the shape of pigs, to puddle it or to stir it about until the mass took the form of a ball deprived of its carbon; it was then placed under the hammer, and formed into slabs or ingots. The next process was to roll it into bars, which being cut into short pieces, were again heated and rolled either into plates or bars as required.

Now the great defect of this process was the unsound state of the iron, as the least rust or scoriæ on the surface of the piled bars prevented the welding or fusion of the metals, and hence followed what are called blistered plates, or laminated bars of unsound construction.

The new process it will be observed obviates all these difficulties, as in the Bessemer process the melted iron is deprived of its carbon by the action of an artificial blast—the same as formerly prevailed on the hearth of the refinery—and thence it is cast into ingots of the weight required, either for the hammer or the rolls. From this it will be seen that the risk of piling and welding is entirely dispensed with, and the article produced, whether of iron or steel, is perfect in its homogeneity. It may be of good or inferior quality, hard or soft, but by this process it is free from the risk of being unsound in its homogeneous state.

As regards the steel, of which we have to submit the results, as produced by the principal manufacturers of this country, it will be observed that in making steel from the puddling-furnace, similar combinations may be produced, but with less certainty as regards

y, as everything depends on the skill of the operator in closing the furnace at the precise moment of time, before the mass is deprived of its carbon. This precaution is necessary in order to retain the exact quantity of carbon in the puddled bulb, so as to produce by combination the requisite quality of steel. It will be observed that in the Bessemer process this uncertainty does not exist, as the whole of the carbon is volatilized or burnt out in the first instance; and by pouring into the vessel a certain quantity of crude metal containing carbon, any percentage of that element may be obtained in combination with the iron, possessing qualities best adapted to the varied forms of construction to which it may be applied. Thus the Bessemer process is not only more perfect in itself, but admits of a greater degree of certainty in the results than could possibly be attained by the mere employment of the eyes and hands of the most experienced puddler. Thus it appears that the Bessemer process enables us to manufacture steel with any given proportion of carbon, or other eligible element, and thus to describe the compound metal in terms of its chemical constituents.

Important changes have been made since Mr. Bessemer first announced his new principle of conversion, and the results obtained from various quarters bid fair to establish a new epoch in metallurgic manipulation, by the production of a material of much greater general value than that which was produced by the old process, and in most cases of double the strength of iron.

These improvements are not exclusively confined to the Bessemer process, for a great variety of processes are now in operation producing the same results, and hence we have now in the market homogeneous and every other description of iron, inclusive of steel, of such density, ductility, &c., as to meet all the requirements of the varied forms of construction.

The chemical properties of these different kinds of steel have been satisfactorily established; but we have no reliable knowledge of the mechanical properties of the different descriptions of homogeneous iron and steel that are now being produced. To supply this desideratum, I have endeavoured, by a series of elaborate experiments, to determine the comparative values of the different kinds of steel, as regards their powers of resistance to transverse, tensile, and compressive strain.

These experiments have been instituted not only for those engaged in the constructive arts, but also to enable the engineer to make selections of the material as will best suit his purpose in any work proposed. In order to arrive at correct results I have applied to the first houses for the specimens experimented upon, and judging from the results of these experiments, I venture to hope that new and important data have been obtained, which may safely

be relied upon in the selection of the material for the different forms of construction.

For several years past, attempts have been made to substitute steel for iron, on account of its superior tenacity in the construction of ships, boilers, bridges, &c.; and there can be no doubt as to the desirability of employing a material of the same weight and of double the strength, provided it can at all times be relied upon. Some difficulties, however, exist, and until they are removed it would not be safe to make the transfer from iron to steel. These difficulties may be summed up in a few words, *viz.* the want of uniformity in the manufacture, in cases of rolled plates and other articles, which require perfect resemblance in character, and the uncertainty which pervades its production. Time and a close observation of facts in connection with the different processes will, however, surmount these difficulties, and will enable the manufacturer to produce steel in all its varieties with the same certainty as he formerly attained in the manufacture of iron.

In the selection of the different specimens of steel, I have endeavoured to obtain such information about the ores, fuel, and process of manufacture as the parties supplying the specimens were disposed to furnish. To a series of questions, answers were, in most cases, cheerfully given, the particulars of which will be found in the experimental Tables, published in the Transactions of the British Association for 1867.

I have intimated that the specimens have been submitted to *transverse, tensile*, and compressive strain, and the summaries of *results will indicate the* uses *to* which the different specimens may *be applied. Table* I. *gives for each* specimen the modulus of elasticity, and the modulus of resistance to impact, together with the deflection for unity of pressure*;* from these experimental data the engineer and architect may select the steel possessing the actual quality required for any particular structure. This will be found especially requisite in the construction of boilers, ships, bridges, and other structures subjected to severe strains, where safety, strength, and economy should be kept in view.

In the case of transverse strain some difficulties presented themselves in the course of the experiments, arising from the ductile nature of some part of the *material,* and *from its tendency to bend* or deflect *to* a considerable depth *without fracture.*

But this is always the case with tough bars, whether of iron or steel, and hence the necessity of fixing upon some unit of measure of the deflections, in order to compare the flexibility of the bars with one another, and, from the mean value of this unit of deflection, to obtain a mean value of the modulus of elasticity (E) for the different bars. This unit or measure of flexibility given in the Table, is the mean value of all the deflections corresponding to unity of

pressure and section. In order to determine the resistance of the bars to a force analagous to that of impact, *the work* in deflecting each bar up to its limit of elasticity has been calculated. These results differ considerably from each other, showing the different degrees of hardness, ductility, &c., of the material of which the bars are composed. The transverse strength of the different bars up to their limit of elasticity is shown by the amount of the *modulus of strength* or *the unit of strength* calculated for each bar.

Table II., on Tensile Strain, gives the breaking-strain of each bar per square inch of section, and the corresponding elongation of the bar per unit of length, together with the ultimate resistance of each bar to a force analogous to that of impact.

Table III., on Compression, gives the force per square inch of section requisite to crush short columns of the different specimens, with the corresponding compression of the column per unit of length, together with the work expended in producing this compression.

It will be observed from the following Tables that the results of the experiments show that the deflections produced by a transverse strain are in proportion to the pressures within the limits of elasticity.

In Table I., as in the other two on tension and compression, the value of the work done on each specimen has been determined, and the results recorded in the last column indicate the comparative strength of each particular bar; and the mean value of the deflections corresponding to unity of pressure and section will be found in column 3. These may be taken as the measure of flexibility, elasticity, and ductility of the different bars, and the uses to which the material may be applied.

The mean value of E, the modulus of elasticity taken for thirty of the best specimens, is about 31,000,000, which exceeds that of wrought iron by more than the thirtieth part. Steel having a much greater flexibility than malleable iron, accounts for the approximation of their respective values in D_1. This arises from the fact that the bars of the greatest flexibility—other things being the same—have the least value for the modulus of elasticity.

On tensile strain *the mean result derived from thirty of the best specimens is 47·7 tons, or nearly 48 tons per square inch; and in this, as in the previous Table, the measure of ductility* and strength is given in the last column, which indicates the utility of the material and the purposes for which it may be selected.

Comparing the best quality of steel with the best wrought iron at 24 tons as the breaking-weight per square inch, we find that we have a material of double the strength with the same weight, or what is the same thing, of only half the weight with the same strength, or as 47·7 to 24. In the art of construction these

COMPARISON of STEEL MANUFACTURED after the BESSEMER PROCESS, with that MANUFACTURED by other PROCESSES.

TABLE I.—TRANSVERSE STRAIN on inch-square bars, and 4 ft. 6 in. between the supports.

MANUFACTURER.	Description of Steel.	Mean value, D_1, of the deflection for unity of pressure and section.	Mean value of the modulus of elasticity E.	Mean work of deflection, u, for unity of section.	Mean value of C, the unit of working strength.	REMARKS.	
					tons.		lbs.
Messrs. J. Brown & Co.	Bessemer steel	·0012739	30,730,000	52·721	5·918	Mean breaking weight	1000
Messrs. C. Cammell & Co.	,,	·0013518	29,166,000	59·897	5·921	Do.	950
Messrs. H. Bessemer & Co.	,,	·0016684	29,813,000	49·489	5·659	Do.	975
The Hæmatite Steel and Iron Company	,,	·0014590	27,153,000	26·463	3·914	Soft steel.	
Mean	.. ..	·0014382	29,215,000	47·142	5·283		
Messrs. Naylor, Vickers, & Co.	Melted in the crucible	·0013007	30,278,000	65·049	6·548		
Messrs. S. Osborn & Co.	,,	·0014296	27,482,000	52·574	5·622	Mean breaking weight	1250
Messrs. C. Sanderson & Brothers	,,	·0013209	29,973,000	47·411	5·521	Do.	1250
Messrs. T. Turton & Sons	,,	·0013120	30,294,000	52·680	5·886	Do.	1200
The Titanic Steel and Iron Company	Mushet's steel	·0012350	31,901,000	63·542	6·435		
Mean	.. ..	·0013196	30,012,000	56·251	6·002		

TABLE II.—TENSILE STRAIN on bars ¾ inch diameter. Elongations taken on 8 in. length.

MANUFACTURER.	Description of Steel.	Specific Gravity.	Mean weight laid on in lbs. producing rupture.	Mean breaking strain per square inch of section.		Mean elongation, per unit of length.	Mean value of u, or work producing rupture. By eq. 13.
				lbs.	Tons.		
Messrs. J. Brown & Co.	Bessemer steel	7·7665	33,603	90,379	40·35	·0460	2002
Messrs. Cammell & Co.	.. ..	7·8119	34,085	101,132	45·14	·0595	2714
Messrs. Bessemer & Co.	.. ..	7·7726	38,189	89,955	40·15	·0753	3212
The Hæmatite Steel and Iron Company	.. ..	7·7951	33,321	72,195	32·22	·0342	3351
Mean	.. ..	7·7891	34,299	88,415	39·46	·0582	2819
Messrs. Naylor, Vickers, & Co.	Melted in the crucible	7·8198	39,449	108,099	48·25	·0372	1827
Messrs. S. Osborn & Co.	,,	7·7758	44,131	103,214	46·07	·0341	1842
Messrs. C. Sanderson & Brothers	,,	7·7563	39,592	95,553	42·65	·0229	1566
Messrs. T. Turton & Sons	,,	7·7990	39,295	93,380	41·61	·0165	807
The Titanic Steel and Iron Company	Mushet's steel	7·7883	37,179	93,616	41·79	·0551	2413
Mean	.. ..	7·7878	39,923	98,772	44·07	·0327	1691

COMPARISON OF STEEL — *continued.*

TABLE III.—COMPRESSIVE STRAIN on specimens ¾ in. diameter and 1 in. in length.

MANUFACTURER.	Description of Steel.	Mean weight laid on in lbs.	Greatest weight laid on per square inch of section.		Mean compression per unit of length.	Mean value of *u*, or work expended in crushing the bar.
			lbs.	Tons.		
Messrs. J. Brown & Co.	Bessemer steel	91,840	225,568	100·700	·347	39,101
Messrs. C. Cammell & Co.	,,	91,840	225,568	100·700	·339	38,232
Messrs. H. Bessemer & Co.	,,	91,840	225,568	100·700	·379	42,720
The Hæmatite Steel and Iron Company	,,	91,840	225,568	100·700	·445	50,207
Mean	.. ..	91,840	225,568	100·700	·377	42,981
Messrs. Naylor, Vickers, & Co.	Melted in the crucible	91,840	225,568	100·700	·286	32,300
Messrs. S. Osborn & Co.	,,	91,840	225,568	100·700	·267	30,014
Messrs. C. Sanderson & Brothers	,,	91,840	225,568	100·700	·328	36,906
Messrs. T. Turton & Sons	,,	91,840	225,568	100·700	·398	29,254
The Titanic Steel and Iron Company	Mushet's steel	91,840	225,568	100·700	·315	35,551
Mean	.. ..	91,840	225,568	100·700	·318	32,805

are considerations of great importance; and in every case where steel can be depended upon, it is entitled, on the score of economy and lightness, to the judgment and practical knowledge of the architect and engineer.

In Table III., on compression, each of the specimens were reduced, when cut from the bars previously experimented upon, to small columns of ¾ inch diameter and 1 inch in height. They were each loaded with weights equal to 100 tons per square inch, without undergoing any sensible appearance of fracture. On consulting the Table it will be found that with the above weight of 100 tons per square inch they were compressed, on the average, to two-thirds their original length; and from these facts we were enabled to find the value of *u*, recorded in the last column, as the value of work done by the load which produced the change of form in each of the specimens submitted to pressure. This, it will be observed, was the true test of the powers of resistance of the respective specimens to a compressive strain, and the conditions under which materials of similar properties may be safely applied in constructive art.

On comparing the mean tensile resistance to rupture at 47·7 tons per square inch, it will be seen that the resistance to com-

pression is more than double the resistance to extension, or as 100·7 to 47·7, being in the ratio of near 2 : 1. Hence it follows that the most economic form of a steel bar undergoing a transverse strain would be a bar with double flanges, having the area of the top flange about one-half that of the bottom.

This conclusion is borne out by the results of experiments on transverse strain, where S_1, the strain per square inch of the material at the elastic limit, $= 6\,C = 6 \times 6{\cdot}83$ tons $= 40{\cdot}98$, or 41 tons nearly; but the mean breaking-strain per square inch by extension $= 47{\cdot}7$ tons, clearly indicates that the compressive resistance in the former case was considerably in excess of the tensile resistance.

It is important in every experiment on the strength of materials, which enters so largely into constructive art, that we should be thoroughly acquainted with the properties of the material of which the structure is composed, and that its resistance in all the different forms of strain should be clearly and distinctly ascertained. In the foregoing experiments we have determined the resisting powers of the different specimens to bending, tension, and compression; but we have omitted that of torsion, or twisting, until we have an opportunity of doing so upon the same identical bars. These I hope to accomplish at some future period, and also to give some further results upon an enlarged scale, calculated to confirm what has already been done, and to ascertain some additional facts in regard to the changes now in progress in the manufacture of Iron and Steel.

IV. THE TREASURES OF SILURIA.

Thesaurus Siluricus: The Flora and Fauna of the Silurian Period. With Addenda (from recent acquisitions). By JOHN *J. BIGSBY, M.D., F.G.S.* London: Van Voorst. 1868. 4to, *pp. 268.*

THE "Treasures of Siluria" consist of a vast assemblage of those "Medals of Creation" with which the late Dr. Mantell, years ago, made the intelligent reader familiar. These medals are coins of various denominations, each of which had an unnumbered circulation. But the region over which they severally passed current, and the relative value which belongs to them, are questions which, amongst others, we shall discuss in this article.

At the head of our review we have placed the title of but one book,—not because it gives us every possible information about the "Treasures" whose value we wish to estimate, but because it is a synopsis of everything that has hitherto been published on the subject, and of not a little that is even now in the hands of the

printer. Especially let us mention that M. Barrande's 'Système Silurien du Centre de la Bohême—Recherches Paléontologiques,' Professor, James Hall's 'Palæontology of New York,' Mr. Davidson's 'British Silurian Brachiopoda,' Mr. Salter's numerous works on Silurian fossils, and the Reports of the Canadian Geological Survey, are the great storehouses from which Dr. Bigsby has collected most of his material, while innumerable memoirs by an army of English, Continental, and American authors have yielded to his search an almost equal number of species.

Dr. Bigsby has, indeed, spent a vast deal of time in groping about amongst the archives of a host of ancient cemeteries of all dates and of all climes. He has found records of the burial of numerous groups of individuals, each group being known by a distinct name. Some of these are represented in countries far apart, and during successive periods of lengthened duration; but the majority of them have remained true to their native country, and have not survived the vicissitudes of climate and conditions to which all regions are more or less subject. In other words, as we shall have occasion to point out again, those individuals and communities which emigrated to distant regions flourished and multiplied, after the manner of more modern emigrants, under the more favourable conditions of their new habitation; while those which remained true to their birthplace succumbed during a struggle for existence with either their own progeny or new colonists, aggravated by a decrease in the means of subsistence and a more rigorous condition of external circumstances.

The 'Thesaurus' contains the names, dates, and habitations of nearly nine thousand species, so far as they are at present known. These species are classified zoologically into their respective orders, the genera of each order and the species of each genus being then given alphabetically. At the end of the list of members of each order is given a "geographical summary," showing at a glance the distribution of the genera and their species over the surface of the globe. Finally, at the end of the book is a very complete list of works on Silurian Palæontology, which will necessarily be of great assistance to future students of the subject.

The untiring and long-sustained industry necessary to the successful compilation of a work of this kind is a quality possessed by comparatively few men of science; and while we rejoice that the Royal Society has recognized and rewarded the perseverance of the author by a grant of 100*l.* in aid of the publication of his book, we sincerely hope that the scientific public will follow so distinguished an example, and will preserve the author from pecuniary loss by purchasing a work of reference unique in its aim, and without which every geological library must be regarded as incomplete.

Preceding the lists of species which form the main body of the work, Dr. Bigsby records a number of "Facts and Observations" as the result of his analysis of them. These general conclusions bear even stronger testimony to the author's industry, and much more powerful witness to the vigour of his intellect, than the lists of species themselves. Indeed, if the 'Thesaurus' had been placed in the hands of a dozen Palæontologists, we doubt whether any one of them would have drawn a more original series of inferences than these same "Facts and Observations;" and we are quite confident that a more suggestive series it would be impossible to bring together.

While it would be both tedious and difficult to scrutinize lists of species, it is infinitely easier to criticize conclusions than it is to arrive at them. The reviewer comes to their examination rather inclined to object to them, while the author, on the other hand, having been for weeks, for months, perhaps for years, accumulating and selecting materials which have suggested to him certain inferences, finds it extremely difficult fully to appreciate such hostile facts as would require very serious modifications of his previous results.

Having thus confessed our bias, we will endeavour to guide our readers fairly through some of the paths trodden by our author, and will commence with that very intricate formation known as the "Primordial Zone."

Although the commencement of what is still included in the "Silurian System" may not be of the greatest importance to the registrar of the births and deaths of Palæozoic fossils, there is no doubt whatever that it possesses the highest interest for the scientific theorist. The "Primordial Zone" must, in fact, be still looked upon as practically the natal epoch of organic life, for the inhabitants of the vastly more ancient Laurentian period are still too little known to enable the Palæontological genealogist to deal with them.

Dr. Bigsby devotes three or four pages to a brief sketch of the salient facts connected with his census of the inhabitants of the Primordial Period, but owing to his apparent desire to extend its limits, he is obliged to commence with the following sentence:—"Waiting for the results of the investigations now taking place in Canada as to the exact relations of the Quebec Group with the Primordial Stage, it will be better not to dwell long on this part of the Silurian Epoch, especially as the present ideas on these relations do not give entire content." He further remarks that "it is indissolubly Silurian by almost every possible tie—by facies, materials, stratigraphy, and organic contents,"—but in this latter *conclusion he will not be supported, we think, by our working Welsh geologists.*

Dr. Bigsby gives us an imposing summary of the fauna of the Primordial Zone in Europe and America, namely, 375 species in the former, and 597 species in the latter region; but his definition of the formation is so extremely wide that it is difficult, from his figures, to arrive at the real value of the fauna of the period in its more restricted meaning. To prevent any misunderstanding, we give the following comparative statements of what is usually included in this formation, and of what the author includes within its definition:—

BRITAIN.

Bigsby.		Murchison, Belt, Salter, &c.
Lower Llandeilo Skiddaw Slates Arenig Group	Lower Silurian of other authors.	
Stiper Stones Tremadoc Slate	.. ..	Tremadoc Group.
Lingula Flags ..	.. ..	Ffestiniog Group (Sedgwick). Mænevian Group (Salter).
Harlech Grits ..	.. ..	Harlech Group.
Llanberis Slates	.. ..	Llanberis Slates.

CANADA AND UNITED STATES.

Bigsby.		Murchison.
Quebec Group	Chazy Limestone (part). Calciferous Sandstone. Point-Lévis Rocks.	
Potsdam Sandstone ..	.. ..	Lower Calciferous Group. Upper Potsdam Group. Lower Potsdam Group. St. John's Group.

It is thus seen that Dr. Bigsby adds to what is usually termed "Primordial" in Britain, the Lower Llandeilo of Murchison (the Arenig Group and the Skiddaw slates being also of that age), while his classification of the American rocks is still more complicated. According to Sir R. I. Murchison the Lower Calciferous Group is succeeded by (1) the Upper Calciferous Group, and (2) the Quebec Group (including the Lévis, Lauzon, and Sillery rocks), both being regarded by him as of Llandeilo age; and these are again surmounted by the Chazy Limestone, which Sir Roderick refers to the base of the Caradoc formation, but part of which Dr. Bigsby (as we have seen) also includes in the Primordial Zone!

With respect to Bohemia there can be no difficulty, as there, of course, the Primordial Zone is simply the Primordial Zone, the "First Fauna," the C.c.1 of M. Barrande. The question is, What are its equivalents in Britain and America? Or, to bring the matter to a closer issue, Is Dr. Bigsby right in his extension of the definition for Britain and America? We cannot decide this question; but we are obliged by every rule of classification and of

argument to assume that the old ideas are correct, until they have been proved to be erroneous. The *onus probandi* lies with Dr. Bigsby, and he has not advanced a single argument in support of his novel classification.

We can allow ourselves to notice but one other conclusion of our author in connection with the Primordial Zone, and that only in relation to the general question of the origin of life. Dr. Bigsby remarks, "The Primordial stage did not start forth, Pallas-like, at once, in full maturity."* This is quite true. In the Llanberis or Bangor slates no fossils have hitherto been discovered, while in the Harlech Grits above, the number of species, and of represented genera, though certainly small, is somewhat uncertain, from the bad state of preservation of many of them; but in the still higher Mænevian group we meet with a tolerably rich and varied fauna. Dr. Bigsby's idea is, that "the quantity, variety, and high rank of its fauna shut us up from any other conclusion than that it is only part, and a rich part, of an already established flora and fauna lying undetected at present."† No doubt this inference is very just, and it is certainly one in which we cordially agree; but we feel some difficulty in reconciling it with our author's dictum of the necessity of "Radiata, Mollusca, Annelida, Articulata, all showing themselves simultaneously, or nearly so."‡

The *first appearance of species*, however, the author discusses very briefly. It is, in truth, a subject on which very few facts can at present be quoted. His proposition that "life started into being, necessarily, in societies both composite and simple," § besides appearing to contradict one of his inferences respecting the Primordial fauna, will probably not meet with general acceptance, although the exact meaning to be ascribed to it seems to us a little doubtful.

Leaving this speculative subject, we will examine some of the many curious facts which illustrate the *duration of species*, which is a matter of very high interest. For instance, M. Barrande has shown ‖ that 32 species of Bohemian Orthoceratites began and ended their existence in one subdivision of the Silurian rocks (E.e.1), while 38 more passed up into the next stage (E.e.2), and there perished. In this latter formation no less than 199 species of the same genus make their appearance, not one of which passes up into the overlying stratum.

In connection with this subject it will be useful to draw attention to Dr. Bigsby's census of the species which are known from only one place,¶ as compared with that of the total number of Silurian species, *viz.*:—

* P. xx. † Ibid. ‡ P. xxxvii. § Ibid.
‖ See 'Thesaurus,' p. xxxviii. ¶ Pp. vii. and xxxvi.

Groups.	Total Species.	Species of one Locality.
Plantæ	82	47
Amorphozoa	136	92
Foraminifera	25	0
Cœlenterata	507	220
Echinodermata	500	365
Annelida	154	88
Cirripedes	8	6
Trilobita	1611	708
Entomostraca	318	198
Polyzoa	441	265
Brachiopoda	1650	699
Monomyaria	168	87
Dimyaria	541	287
Pteropoda	358	210
Gasteropoda	895	454
Cephalopoda	1454	858
Pisces	37	26
Incertæ sedis	12	10
	8897	4620

The total result is thus seen to be that more than half of the known Silurian species have hitherto been found in only one locality. This fact alone is sufficient to remind us (what Dr. Bigsby quotes) that so thoughtful a naturalist as the late Professor Edward Forbes asserted that a large proportion of all known species of fossils are founded on single specimens.

It is a very remarkable fact that the species which are thus restricted to a small geographical area are also those which attain a small vertical range. Thus, in Bohemia, in two small and adjoining parishes near Prague, we find huddled together no less than 112 species of *Cyrtoceras*, 27 of *Trochoceras*, and 30 of *Orthoceras*, with many other fossils, all of which are confined to one stratum, and none of which have hitherto been found elsewhere.

At the present day large assemblages of species (though their value as such is doubtful), of *one class of animals* exist in certain regions. For instance, the rivers of North America have yielded countless forms of Unionidæ, and those of Brazil (according to Professor Agassiz) no less than 2000 species of fish. These "communities," as Dr. Bigsby calls such populations, had their parallel in Silurian times in Bohemia; for there, in the wonderful deposit E.e.2, which we have already mentioned, no less than 921 species have been discovered in a bed about 150 feet thick, extending over an area not more than 15 miles long by 7 broad. Of this large number, 590 species belong to the order Cephalopoda, and of them no less than 220 species are peculiar to one parish (Lochkov), and 102 to another (Kozorz), while 75 others are common to the two. These 590 species represent only 9 genera, *Orthoceras* including 252 species, *Cyrtoceras* 199, *Gomphoceras*

59, *Trochoceras* 36, *Phragmoceras* 25, and 4 others the remaining 19.

What Dr. Bigsby calls "universality" illustrates the other side of the question in an equally forcible manner. His definition is that "a formation may be considered to be universal when it occupies large and small areas in very many parts of the earth, often remote from, and even antipodal to, each other, when it is always of like stratigraphical relations, is composed of like materials, and contains numerous genera of existences in common, together with some representative, and some identical species." Of course this definition makes the Silurian a universal formation; and if its spirit be truly applicable to a formation, it must be equally so to a genus or a species. Our author has therefore constructed a table, showing that 210 species are common to Europe and America, of which 35 travelled from the Old to the New World (that is, appear in more recent deposits in the latter); 30 from America to Europe; while 145 are what he calls "Isozonals;" that is to say, occur on the same horizon in both hemispheres. At first sight it seems as if Dr. Bigsby were of opinion that the last-named species did not migrate at all, but were sown broadcast over the whole area at the time of their creation. We presume, however, that this is not really his meaning.

Some Silurian species occur almost everywhere where Silurian rocks occur. And it is noteworthy that most of these "universal" species possess also the greatest vertical range, and the greatest variability recognized as such. Take, for instance, the well-known *Calymene Blumenbachii*. This species, though not so variable as some others which might be named, occurs in England in all divisions of the Silurian system, from the Llandeilo to the Wenlock inclusive. And many other instances of a like nature might be quoted. Indeed, our author is well acquainted with them.

As to geographical range, this same *Calymene Blumenbachii*, so well known in the United Kingdom, is found abundantly in the Upper Silurian rocks of Northern Europe, in both the Lower and Upper divisions of the French Silurian strata, and in the Lower, Middle, and Upper divisions in those regions of North America where they respectively occur.

It certainly does surprise us that Dr. Bigsby, in dealing with a topic of such great interest as that of the *duration of species*, should not once allude to the law originally laid down by De Verneuil and D'Archiac, advocated by Forbes, Rogers, and others, and adopted by almost every subsequent writer. This law may be enunciated thus:—Species which are most extended in geographical space are generally those which have the greatest vertical range. It refers specially to organisms of the same rank, and

must not therefore be confounded with the law which ascribes the greatest range to the most lowly organized animals.

The general law of the range of species in space and time may therefore be broadly and roughly stated as follows:—long life and great range; short life and restricted range. Now, without at all doubting the fact that the lives of species, like those of individuals, may vary in length to a great extent, we think that naturalists who "count heads" should satisfy themselves whether a species which has spread ver three-fourths of the globe, and enjoyed an existence extending through several divisions of the Silurian period, is precisely equivalent in Natural History value to a species of the same genus which, with scores of others, was both created and destroyed within the limits of one minor subdivision of the same period, and which never extended beyond an area of a few square miles. To put this question in a concrete form, let us ask whether *Orthoceras annulatum* is of an equivalent value to, say, *O. intermixtum?* The former is a species which ranges from the Caradoc to the Ludlow rocks inclusive, and from New York, through Northern Europe and Great Britain, to Bohemia, while the latter occurs in only one subdivision (E.e.2) of the Silurian system, and in but one small district in Bohemia.

Taking into consideration the whole of the facts, illustrated as they are by the few which we have described, we feel inclined to believe that whereas some species had strong constitutions, and could sustain changes in conditions and the wear and tear of travel with comparative impunity,—in other words, that they possessed great vitality (Dr. Bigsby calls it viability),—others presented more feeble resistance to such untoward circumstances. These latter either died out altogether or became so far altered as to merit new names at the hands of Palæontologists,—who unfortnately are generally (and frequently of necessity) guided only by the laws of convenience and the rule of thumb.

If we are correct in our estimate of the relative value of species, the very awkward question will arise, What inferences can legitimately be drawn from Dr. Bigsby's synoptical tables? In other words, What is the use of "counting heads?" Echo answers, What? And we believe that we may strengthen our position without violating the truth by ascribing this phrase "counting heads," as well as the first denunciation of the practice, to an eminent geologist who at one time evinced considerable skill in its exercise.

We have now discussed at some length the first appearance and the duration of species, and our space compels us to pass on to a hasty review of the causes which have led to and accompanied their extinction. Dr. Bigsby's statements on this subject are not a little confusing, as some of them include the idea of the action of purely local, and chiefly geographical causes, while others are equally dis-

tinct statements of the cosmical (*i.e.* universal) theory of creations and extinctions. For instance, "all beings are subject to external *conditions, favourable and unfavourable, which assist in the production of an average longevity.*" "*Extinction of life is commonly* slow, continuous, individual, and sometimes is more rapid than replacement from without, or than by acts of creation. Sudden acts of extermination are exceptional, brief in time, and limited in space." Again, the author divides the causes of extinction into two classes, (1) mechanical and (2) physiological. The former includes oscillation of level, climate, &c.; and the latter, such matters as supply of food, overcrowding, epidemics, &c.

With all this most students of the modern school will agree; but we imagine that our readers will be as surprised as ourselves to find amidst so much of the "uniformity" philosophy the following sentence:—"The causes of extinction are in universal operation. They are cosmical. Silurian life was discontinued everywhere at the same time, proximately." Surely, if this statement includes the actual fact, mechanical and physiological causes of extinction may as well be neglected, for their operation must have been too restricted to leave any impress on the geological record.

As a corollary of his cosmical theory, Dr. Bigsby states that "There is no example, as far as I know, of a Silurian *community* rising, by migration or otherwise, into Devonian or Carboniferous strata; but single species do, and somewhat largely, just as we see in every epoch up to the present." Our knowledge is not yet sufficiently advanced to enable us to make many definite statements on this subject; but we may remind Dr. Bigsby that his favourite (and deservedly great) authority, M. Barrande, has shown that the two highest members of his Third Fauna (stages G and H) present less strong connections with the Devonian system than do the still older deposits E and F. Again, the author himself admits that "whole communities have been known to return together to the country they had long abandoned," and he quotes Mr. Godwin-Austen's description of "this kind of repossession in the Palæozoic rocks near Boulogne."

From these considerations the author passes naturally to the question of recurrence, which he defines to be "the reappearance of a plant or animal in a zone of rocks higher than that in which it was first observed. It implies progress upwards, either on the same spot or on another by migration." Used in this sense, it is remarkable how many species may be termed recurrent,—what a large number occur on more than one horizon.

In illustration of the subject, Dr. Bigsby has constructed a table showing a synoptical view of Silurian life in this relation as far as was known in 1865. This table shows us that out of the 5968 Silurian species (exclusive of the Primordial) whose places are

well known), 784, or 13 per cent., are recurrents, leaving 5184 faithful to one horizon. But this statement does not describe the scope and value of the table, which may be epitomized as follows:— In the Lower Silurian rocks 354 species occur on two horizons—98 on three, 44 on four, and 5 on five. In the Middle Silurian 95 species occur on two horizons—29 on three, and 3 on four. In the Upper Silurian 138 species occur in two divisions, 15 in three, and 3 in four.

There are many curious facts connected with recurrence, several of which are not yet properly understood. In one region a species may be restricted to one horizon, being there truly typical, while in another region the same species may pass through nearly the whole of the subdivisions of the Silurian series. Speaking generally, recurrence is common in Sweden and Canada, and still more so in Wales. It is rare both in Russia and Bohemia. In the last-named country we have seen that species of short duration and belonging to a small number of genera are extremely abundant. Surely this contrast is another fact in favour of the views we have already advocated.

After reading through the "Facts and Observations," we at first felt somewhat uncertain as to the author's views on the important subject of Contemporaneity of Strata. He does not say much about it; and, with the exception of the first and last sentences which we quote below, his statements do not help us very powerfully to a conclusion.

(1.) "We already have materials from almost all parts of the Silurian scale of rocks to show, with some force (M. Barrande), that life began earlier and more abundantly in the valleys of the St. Lawrence and Mississippi than in Europe." *

(2.) "It would appear that the Silurian system of rocks is universal in extent, and that its component parts were laid down at a proximate time, and in like manner ceased to be laid down, statements approved by M. Barrande." †

(3.) "It is a very striking fact that the great majority of the Silurian fauna made their first appearance on the same horizon—that is, everywhere on, proximately, the same stage or subdivision of the epoch." ‡

(4.) "Silurian life was discontinued everywhere at the same time, proximately." §

(5.) "The Upper Silurian fossils which people the Prague colonies in fauna D.d, except as they come from another area, are not recurrents, are not the posterity of Bohemian mollusks. They are the *precursors* of an identical and larger coming fauna. Signs are not wanting that they come from a country *where the Silurian*

* P. xi. † P. xxiii. ‡ P. xxxvii. § P. xl.

*epoch was more advanced than in Bohemia;** and they become of great value by indicating *local inequality of progress* in the act of deposition during this epoch—suggesting, moreover, that *any of the Silurian stages may be in process of formation about the same time with another in different parts of the world.*" †

Now there can be no doubt that our quotations No. 1 and No. 5 show that the author's mind is fairly imbued with the theory of homotaxis in a legitimate and moderate degree; but the only word in the remaining quotations which can possibly receive a "homotaxeous" construction is proximate or proximately; and it is extremely remarkable that this qualification of otherwise rigorous statements occurs in each of the three remaining sentences (Nos. 2, 3, and 4). In a postscript Dr. Bigsby gives a list of "additional subjects," and amongst them we find the following: "The greater or less *synchronism* of strata far apart; measured, where possible. Was America *inhabited* before Europe, &c.?—as seems probable. On the whole, therefore, we must regard our author, veteran though he be, as a geologist of the advanced modern school, and possessing an elasticity of mind not at all common amongst scientific men of his generation.

V. ON NATIONAL INSTITUTIONS FOR PRACTICAL SCIENTIFIC RESEARCH.

By Lieutenant-Colonel STRANGE, F.R.S., Government Inspector of Scientific Instruments, India Department, and Dr. MANN, F.R.A.S., F.R.G.S., &c., Superintendent of Education, and Special Commissioner of the Government of Natal. ‡

AT the recent Meeting of the British Association for the Advancement of Science, held in the city of Norwich in the month of August last (1868), the Inspector of Scientific Instruments for the India Department brought a subject before the Mathematical and Physical Section of the Congress which had obviously been engaging his attention and thoughts very seriously for some considerable time. In a somewhat lengthened experience in one special department of hard scientific work, Colonel Strange has been led to the important conclusion that unquestionable and vast as has been the service pure and practical science has received from the hands of British contributors, this service has not been commensurate with the proud and

* These and the following italics are ours.

† P. xlvii.

‡ The authors are the Chairman and Secretary of a Committee appointed by the British Association for the Advancement of Science, at its Session in Norwich, August, 1868, for the investigation of this subject.

deserved position Great Britain has taken up among the advanced nations of the world on other grounds, and that there is one very clear and obvious reason for this undesirable fact which cannot be too soon looked fairly in the face by the best friends and advocates of scientific movement. The Colonel pointed emphatically to the official declaration, that "The objects of the British Association are to give a stronger impulse and more systematic direction to scientific inquiry, and to remove any disadvantages of a public kind which impede its progress," and upon that manifesto based an argument that there is now an imperative call and claim upon the enlightened Association of British Philosophers to take action upon this avowed principle, and use its powerful influence to lead the public mind to a recognition of one great need from which the highest interests of the general community are suffering at the present day. In this appeal Colonel Strange urged the Association to bear well in mind the importance of pressing upon public attention the *comparatively* backward condition of scientific research in the British Islands and dependencies at the present time, and of insisting upon the inexpressible and unassessible value of the mighty engine of human advancement that is thus allowed to remain in relative idleness and disuse, while so many other engines are worked at their utmost speed, and often with a reckless profusion of expenditure, that only makes the contrast so much the more startling and humiliating for a people aiming at a forward position and high excellence. If the views entertained by the originator of this movement be substantiated by facts, there can be no doubt that an association of philosophers which professes to engage itself with "giving a stronger impulse and a more systematic direction to scientific inquiry, and with removing disadvantages that impede its progress," will be bound by its own profession to do all that may be done to indicate how "the intellectual glories and material riches which a bountiful Providence has created for man's use may be best placed, promptly and systematically, at man's disposal."

The plea which was offered at the Norwich Meeting of the British Association by Colonel Strange was at any rate so far admitted by the court before which he elected to urge the appeal that a committee, comprising the names of Thomson, Tyndall, Frankland, Williamson, Stokes, Fleeming Jenkin, Hirst, Huxley, Balfour Stewart, Stenhouse, Glaisher, and Huggins, besides those of the chairman and secretary, was appointed to consider and report upon the general questions, whether there exist in the United Kingdom of Great Britain and Ireland sufficient provision for the vigorous prosecution of physical research, and whether, if it be held that sufficient provision does not exist, it can be shown what further provision is needed, and what measures can be taken to supply the want.

It will be observed that in this proceeding the action of the

British Association has been purposely and carefully limited to the altogether unexceptionable object of inquiring whether sufficient facilities for the prosecution of scientific research, properly so called, do exist in the kingdom of Great Britain; and of suggesting in what direction it seems most advisable to seek increased facilities, if such are deemed to be required. Whatever scientific men may think of other branches and bearings of this subject, there can be no doubt that there will be at any rate an unanimous consent to enter fairly and fully upon the underlying question of need, and to face, in the most open and unreserved way, the first count of Colonel Strange's indictment. It will be apparent, from the mere title of the paper which was read at the Meeting of the Association by Colonel Strange, namely, "On the necessity for *State Intervention* to secure the Progress of Physical Science," that he has quite made up his own mind that it will be abundantly apparent there is the need, and that there is but one way in which that need can be promptly and efficiently supplied. But from the discussion which followed upon the reading of the paper, it was obvious there are men of high purpose and clear thought in the ranks of British Philosophy who are conscious of the need, but who do not now feel that there is but one way in which the defect can be remedied, and the deficiency supplied. It is therefore imperative that in the first instance the investigation shall be entered upon in the broadest and most cosmopolitan spirit, and that the evidence sought shall be of the freest and most exhaustive character.

In the face of the course that has been determined upon by the Committee of the Mathematical and Physical Section, and by the Council of the British Association for the Advancement of Science, it would be both presumptuous and premature to venture any decided opinion as to either of the questions that are to be made the subject of consideration. But there are certain views of the matter that rise to the surface, out of the arguments that have been already advanced in the preliminary handling of the question, which it will be found advantageous at once to fix as clearly and definitely as possible in the public mind, in order that there may be no unnecessary confusion and misapprehension in regard to the main issue.

In the first instance it must be distinctly understood that even in the extremest form and scope of Colonel Strange's plea there is really nothing that is "revolutionary," or even fundamentally new. *In practice, mankind has been already constrained to admit that there is absolute need for "state intervention"* in carrying forward the work of scientific investigation. It is out of this absolute need, and of mankind's all but universal recognition of it, that have arisen state observatories for astronomical research. All such astronomical investigations as require sustained and continuous

systematic observation, as for instance, the construction of planetary tables, the perfection of the lunar theory, and even the cataloguing of the stars, have been carried on through the intervention of state establishments. No one, even for a passing moment, doubts that in these particulars the mode of carrying on the work has been an advantageous one. Indeed it is not possible for even the most ardent imagination to conceive that the results which have been arrived at in these especial departments could have been secured in any other way. It would certainly be worth while to ascertain the opinion of the Astronomer Royal as to what, in all human probability, those results would have been if all labour of this class had been left to private ardour and enterprise; if such things as tables of the moon had been exclusively contributed by some few dozens of private observers, each following his own notion of the best way of observing and the most convenient way of reducing.

But state intervention has not been confined even to this high branch of scientific labour. It has been in reality found that there are various other departments of intellectual investigation that can only be carried on by the same operation. All the great measures of the earth have been "interventions" of the state, and not contributions of private enterprise. To the state is due all that has been done for preserving in uncontaminated integrity the national standards of length, weight, and capacity. What private or simply co-operative agency could have secured the result which has been already attained at Bloomsbury and South Kensington? To say nothing of the obvious future of the magnificent collections that are gathered in the national museums located there. The influence for good, of the School of Mines in Jermyn Street is now widely recognized and accepted, and that certainly is an establishment that could not have been organized and supported otherwise than by the state. The Kew Observatory, although not a state institution, is a very noteworthy instance on the same side of the argument. It proves, in the first place, the excellent result of substituting organization for desultory individual effort. Before its creation efficient instruments for delicate meteorological and magnetic investigation were scarcely to be procured. It is now the generally recognized authority for the verification of such instruments, and in addition to this main work, other very refined and important investigations are carried on there, which certainly would not be undertaken by individual enterprise; as, for instance, researches relating to the freezing-point of mercury, the rotation of discs in vacuo, and the record by photographic agency of important features presented in the sun's face. Now, this year it has only been found possible to devote the paltry sum of 600*l*. to the support of this useful institution. Who would hesitate to say that in this case usefulness is limited by income, and that under the enjoyment of a more adequate provision from the

state, the services rendered to the community at large by this observatory would be very largely increased?

It may thus then be taken for granted that the abstract question, whether scientific investigation shall be aided, and even carried on, by the state in Great Britain, has been already settled by the irresistible verdict of circumstances. It has been found that certain most valuable and important results can only be secured by this agency, and so soon as the nation has been educated to the point of perceiving that those results are wanted for its service, the agency is set to work. All that remains now to be determined is, whether as much has been done in this direction as the best interests of the nation require, when a keen competition has been established between the foremost nations of the world in this particular; whether there is any special and definite line by which an influence, so grandly beneficial in its results where it has been tried, shall be limited in its application.

But in approaching this portion of the consideration, there is one very curious point that has risen into some prominence, as a direct consequence of the discussion having been opened out at the Meeting of the British Association at Norwich; the difficulty, namely, which there seems to be of getting men generally to understand that the want now urged is not a portion of that larger want of a provision of scientific education for the masses as a portion of general instruction. Almost every person who spoke at the Meeting of the British Association fell into this confusion and argued one way or the other upon the educational ground, although *the originator of the discussion had* most clearly and definitely limited his meaning and object in this particular by the statement that "there should be established a system of national institutions for the sole purpose of advancing science by practical research, *quite apart from teaching it.*" It seems as if, in consequence of the popular agitation that has recently arisen for the introduction of scientific subjects into general education, men at once jump to the conclusion, when anything at all is said about advancing science, that this is the thing that must be meant. It cannot, however, be too clearly comprehended that these two matters, the "*teaching*" and the "*advancing*" science, are entirely distinct. They are allies in the great work of human improvement, and touch upon each other's limits at certain points, in a friendly way, but they are intrinsically and essentially distinct both in their objects and methods. A student in science has to be taught the leading elements, or it may even be all the elements known at the time of the teaching. It would be inexpedient, even if it were practicable, to tell him of researches still in progress. The necessity of the case requires that his attention shall be strictly confined to what is held to be certain and known. The teacher of science, on this account, has to

go year after year through the same course of instruction, scarcely varied or touched by the action of current discovery, and the appliances which his especial work requires are comparatively limited, because they are unvarying, and have to be used over and over again. It is even questionable whether the mind of the formal teacher does not to some extent take the mould of his labours, and become a little stationary and disinclined to forward movement. The cultivator of science, on the other hand, commences his action at the point where the student leaves off. He is, in fact, the student emancipated from the trammels and leading-strings of the teacher. He has ceased to ask, "How is such a thing known?" and in the place of the question adopts the declaration, "Such and such things are not known, and must be ascertained." From copying, and repeating, and verifying, he turns to *creating*. The two processes, the teaching and the extending of science, cannot really be advantageously carried out by the same persons or by the same means. That the two things *are* practically recognized as distinct, is sufficiently proved by the fact that up to the present time we have had no scientific education in England, although we have had great scientific activity, and have effected great, although insufficient scientific progress.

It is obvious that the extensive, or general adoption of science as one of the branches of formal education for the people, will tend to increase the number of persons who will subsequently incline to enter upon the labours of investigation, and that, in this way, scientific education does indirectly favour scientific research. Some competent authorities, indeed, hold that teaching is a direct aid to the cultivator of science, because it keeps him well up in elementary knowledge and stimulates him to the discovery of new proofs and illustrations, and because it brings him into frequent contact with fresh and vigorous, though partially cultivated minds. If this be so, it is clear that the teaching of the cultivator of science would not be the teaching that is contemplated in the routine of scientific education, properly so called. It must be applied in advanced classes only, organized and arranged to ensure the special advantage without profuse and wasteful expenditure of energy, worthy of higher and better employment.

The way in which increased facilties for extending the bounds of human science must influence scientific teaching is too manifest to need that more than a passing word should be devoted to its consideration. Every great fact drawn by the investigator from the unfathomed immensity of the unknown, is a contribution made to scientific teaching through all lands, and for all time. But besides this the augmentation of facilities for prosecuting scientific research will naturally render the student of science more earnest and more willing in placing himself, through the advantages of

formal education, in the position from which independent research may be advantageously entered upon. Indeed, it may be roundly said, that a very considerable portion of the efforts of scientific education will have been made wastefully and uselessly, unless the best men who have been inclined to scientfic investigation by their teaching, are enabled to follow out the bent of their inclination through some door especially opened on their behalf.

It has been shown that the influence of the state has been recognized in Great Britain as a legitimate and wise means of securing to the community the advantage of certain scientific operations that could not be carried on with effect by any other instrumentality in the existing state of society. The argument built upon this fact is very largely strengthened when it is remarked, that the same necessity is not only recognized and acted upon by other civilized and enlightened states, but that for the most part such other states much exceed Great Britain in the liberality and even munificence with which they furnish organizations and material means for the prosecution of scientific research. It is matter of the most familiar remark and comment in what a princely way observatories of all kinds are equipped and supported in Russia. But perhaps the most telling instance that could be adduced in this particular, would be the magnificent Chemical Laboratory just completed at Berlin, from Professor Hoffmann's designs. The building has been erected by the Government, at a cost of about 50,000*l.* It is an ornamental red brick structure, enriched with terra-cotta decorations, and medallions presenting the features of men who have played distinguished parts in the science of chemistry. The building consists of two quadrangles, so arranged as to secure most efficient lighting everywhere. The lecture theatre is sufficiently capacious to accommodate between 300 and 400 persons; but it is at the same time a completely equipped laboratory in itself. There are other laboratories within the structure for ordinary and for advanced students; and several laboratories for men pursuing specific branches of investigation. One very large and complete laboratory is reserved for the Professor's own use. The weighing rooms are distinct chambers, efficiently cut off from the fumes of the laboratories by intervening spaces. The galvanic batteries are held in glass cases, provided with flues to carry off the corrosive vapours. Powerful air-pumps exhaust a large series of receivers arranged along the wall. The most complete spaciousness prevails everywhere, and great care has been taken to secure the possibility of extension as necessity arises. The primary object of this splendid institution is to afford not only facilities for the students of the university, but the offering ready opportunity for original research is distinctly recognized in the design. It would be well worth while to institute a comparison between this princely building deemed

necessary by our enlightened German neighbours for the encouragement of chemical research, and the sole attempts that have been made by ourselves in the same direction, namely, the Laboratory of the School of Mines in Jermyn Street, and perhaps the Royal College of Chemistry, which is almost a national establishment.

It is pretty generally understood that our colonial dependencies for the most part consider that they are yet too young to have much to do with the cares of providing means for the encouragement or prosecution of science. There is a constant tendency in their free-and-easy life to scatter and spread rather than to concentrate. So long as there are millions of acres of unoccupied wastes just beyond the outposts of the last appropriated settlements, asking men to come and possess them, our colonists hold that it is not necessary for them to trouble themselves about the progress of science. This is so much the case, that the great leviathan prototype of colonization, the Transatlantic Republic, even now distinctly avows that its own proper functions are to diffuse, rather than to create; to send the wave of civilization onward into the wilderness, rather than to increase its depth or force. If this be so, it is a correlative consequence of the position that lands otherwise circumstanced, as is the case with the British Isles, where there is a rapidly increasing population but a rigidly limited territory and no room for overflow, must especially take to themselves the work of creation, and aim at standing in the van in that particular mode of developing and applying power to which small islands are adapted by the actual exigencies of their existence. For this reason alone "Great Britain," of all the nations of the earth, ought to be the most munificent and cordial patron of science in any and in every form, as the one beneficent genius to whom it has owed so much of its "*greatness,*" and to whom alone it can look for the preservation of its greatness on its sea-girt throne in time to come. Yet in the face of this obvious consideration there arises the remarkable circumstance, that at the present time Great Britain has not a single first-class telescope at work with adequate optical power for the refined investigations that are now pressing upon the notice of the astronomer, while one of her colonial dependencies in the opposite hemisphere has just completed an instrument of this class at large public outlay. In all probability results will be secured in the spectroscopic analysis of the light of faint stars that fail to show spectral signs to smaller instruments, through this enlightened act of the Melbourne Government, which will give further point to the argument now on hand.

It is an important peculiarity of science, viewed as a branch of human pursuit and industry, that there is literally no limit to either the objects of investigation or the necessity for continuous inquiry. Phenomena of apparently the most trivial character

commonly prove to be the first steps to deductions and discoveries that revolutionize the conditions of civilized society. Every point that occurs as involving some insufficiently examined element, must be viewed as a herald that promises to increase and compact man's knowledge of law and his power over material nature. No one who had chanced to observe the Bologna Professor of Anatomy's pretty and apparently somewhat puerile dealing with the contractions of dead frogs, could ever have conceived that there was in those experiments the first step towards the utilization of a power which was waiting the bidding of human intelligence to cover the earth with a network of instantaneous communication, and to enable men to converse and consult together with safety and ease, while boisterous oceans of thousands of miles' span were heaving between them. If the lead of Galvani's experiment had not been tracked out as it was, electric telegraphy would most probably still have been an art of the future. But if there had been in Galvani's days more adequate provision for seizing and following out that lead, it is equally probable that the Atlantic would have been bridged by the electric cable at a still earlier date in human history, and that men would have been now gathering harvest from the discovery that is not yet attainable. No one who watched the philosophers of Newton's day, amusing themselves with the production of the rainbow spectrum from coloured light, could have conceived that the little prism of glass was an instrument capable, in the hands of more modern philosophy and more advanced intelligence, of actually sounding the material conditions of the worlds and suns of space, severed from man's theatre of action by such awful voids that the mind of the investigator yet fails altogether to *realize the extent of the span through* which the investigation is *conducted. No one who then looked at the little prism could have imagined that by it the secrets of the sun's fires were to be revealed*—that by it the red flames of the total Solar Eclipse, then only observable during about six minutes at rare intervals, would be turned into objects of daily and continuous study and record,—that by it the proper motion of the remote fixed star, which was rushing directly away from the observer, would be detected and measured. Yet *all this has now been accomplished by the application of the prism to the* Spectroscope, *and it is manifest to every thoughtful* mind that this wonderful instrument is only yet on the threshold of a mighty career.

But it should be at once understood that, whilst every point of suggestion and possible investigation should be eagerly seized and surely tracked, a natural division of the labour is fixed by circumstance. There are investigations quite sure to be provided for by individual taste and enterprise; while there are others that necessarily require forethought and organization, and that will never be

carried out unless they are insured in some way by the action and at the cost of the general community. The exact line of this practical distinction will, in all probability, be found to be settled by the need for expensive appliances, permanently appropriated buildings, and continuous action steadily sustained through long periods. These are the conditions which private enterprise cannot and, excepting in the rarest instances, will not provide, and which will not be furnished unless they are supplied on the urgent call of an enlightened community sensible of their need. To take as one prominent instance of the field that has to be occupied by system and organization: How numerous are the sustained investigations that are required into the properties of the various materials employed in the useful arts! Who can yet explain the thousand forms which are assumed by iron, and the thousand changes the metal undergoes under the slightest variety of handling? all of which have direct bearings upon the economies, and, in these recent days of multiplied marvels, even upon the safety of human life. The ordinary alloys of the mechanic—brass, gun-metal, bell-metal, and their congeners,—are all universally cast by the rule of thumb. Upon a recent occasion, when it was found to be highly desirable to introduce large castings of aluminium bronze into the frames of the large theodolites prepared to bear the strain of central stations of observation in the Indian Geodetical Survey, this was done to a considerable degree with the most promising effect, but it was found to be absolutely impracticable to carry the principle out to the desired extent, on account of the want of all appliances for dealing with such masses of a new alloy. In yet higher branches of the application of science, man is still more in the dark. The most intelligent mechanics at this moment know literally nothing as to what is the best material for the construction of the linear measures, on the truthfulness of which all the value of geodetical measures depends; neither can they say whether any material that can be employed for this purpose will retain its dimensions and co-efficient of expansion unaltered through long intervals of time. This one investigation alone requires a special building devoted to the task, and long years of close, continuous, and systematic observation. If there were such a thing as a building properly devised and prepared for investigating generally the properties of the metals, fresh work and useful results would never fail it, so long as metals are used by man. The course that has been taken by the Prussians in forming the Hoffmann Laboratory at Berlin is certainly one which may be accepted as an example of one way in which the forward movement of science may be quickened without entailing any risk of doing harm as well as good. If buildings designed for special work were placed not in, but accessibly near, to the largest and most important towns of the kingdom, combining

in their construction the four prime essentials of rigid stability, free command of light, provision for the maintenance of any required temperature, and quietude, so that they could be used by all who could show that they had really work to do in them, the cost of their establishment would most certainly very soon be returned manifold to the community.

For the thinkers and social philosophers of England should never lose sight of one great fact that underlies this question, and certainly will continue so to do under all circumstances and events; —namely, that scientific work richly pays the community, but *does not pay the man.* Upon the whole it may be said that the chief discoveries in human knowledge are made by individuals who labour hard at some daily drudgery for a livelihood, and then spend their savings and, as innumerable dark pages of human history show, too often something beyond their savings, to benefit their kind, carrying, as their own reward for the work, privation and impoverishment to the brink of early graves. It certainly is no very rash or bold step to assume that something is wanting in social arrangements where this has to be said of a nation that is at the present time adding millions of pounds sterling every year to its accumulated wealth, in the main drawn from improvements in science.

The large world of scientific men, properly so called, are upon the whole ripe for the recognition of the need for some kind of increased facility for carrying on severe research. This is at once apparent whenever the topic is introduced in general conversation. The main point of difficulty, so far as scientific men are concerned, is the question of the best means of doing what is admitted to be so imperatively called for. Many in the ranks of science believe that the work would be most surely and most satisfactorily performed by the Government, and that it even could be efficiently performed by no other agency. Others, on the contrary, conceive that scientific men can manage their own affairs best, without any extraneous interference, and that any meddling of the state would tend to cripple and lethargize, rather than to quicken and strengthen. There is obviously much to be said on both sides in this particular bearing; and it is therefore well that the issue should be fairly joined, and that much should be said, as now certainly will be the case.

The objection of scientific men to state action seems, however, principally to rest on a threefold ground. There seems to be a sort of general notion that statesmen do not know much about science. Added to this there is the strong fear that if the state subsidized and directed scientific investigation, science would work in leading-strings, instead of in the absolute freedom which is the first condition of her own being, the very breath of her life. And then again there is the notion that where the state has a finger there will be

patronage, and preference of inferior agents, who have the support of friendly recommendations, to superior agents who are standing alone.

In regard to this point of view it will not be necessary to say more at present, than that these objections are all properly applicable to state "*maladministration*," rather than to state *action*. The notion that the government of an enlightened community should concern itself with facilitating and quickening the knowledge and intelligence of the people, of course presumes that the government is to be one that is in every sense worthy of the important trust. There can be no doubt that if a government is not worthy of this great trust, and is not capable of carrying out this important object, it is not worthy of being held to be a government at all. A writer in a recent number of the 'Student' has very tersely and admirably touched upon this aspect of the matter, and has given pointed expression to the true principle that has to be looked to in regard to it. He says, "As civilization advances, and political liberty extends, hostile distinctions between governments and people pass away, and nations tend to organize themselves as great co-operative societies, turning the central power in any direction consistent with individual rights, and likely to be productive of general good. *There ought to be no fear of investing properly constituted governments with too much power of being useful*, though there may be great necessity for constituting efficient safeguards and checks against abuse. Human progress is not likely to diminish the sphere of state action, but, on the contrary, to increase it." It is surely true that in few branches of state action have the evils alluded to less to be feared than in relation to the adoption of formal measures for the extension of science. So far as the experiment has been tried, there has been ample guarantee that where science is concerned, distinction and acknowledged ability do outweigh all other influences and considerations of whatever kind, and to an extent certainly not encountered in other departments of the public service. It is enough in illustration of this to point to the names that are found at the head of four important departments where circumstances have compelled a considerable amount of state action. An Airey directs the National Observatory. An Owen looks after the Natural History Collections of Bloomsbury. A Hooker, after years of tried and arduous labour among the Himalayas, is the presiding spirit of the treasures and glories of Kew; and in the young Mineralogical School in Jermyn Street are encountered such names as Murchison, Warrington Smyth, and Huxley.

It should also most certainly be remembered that in one particular sense science-extension enjoys a remarkable immunity from danger of noxious contamination, issuing from state contact, even over its

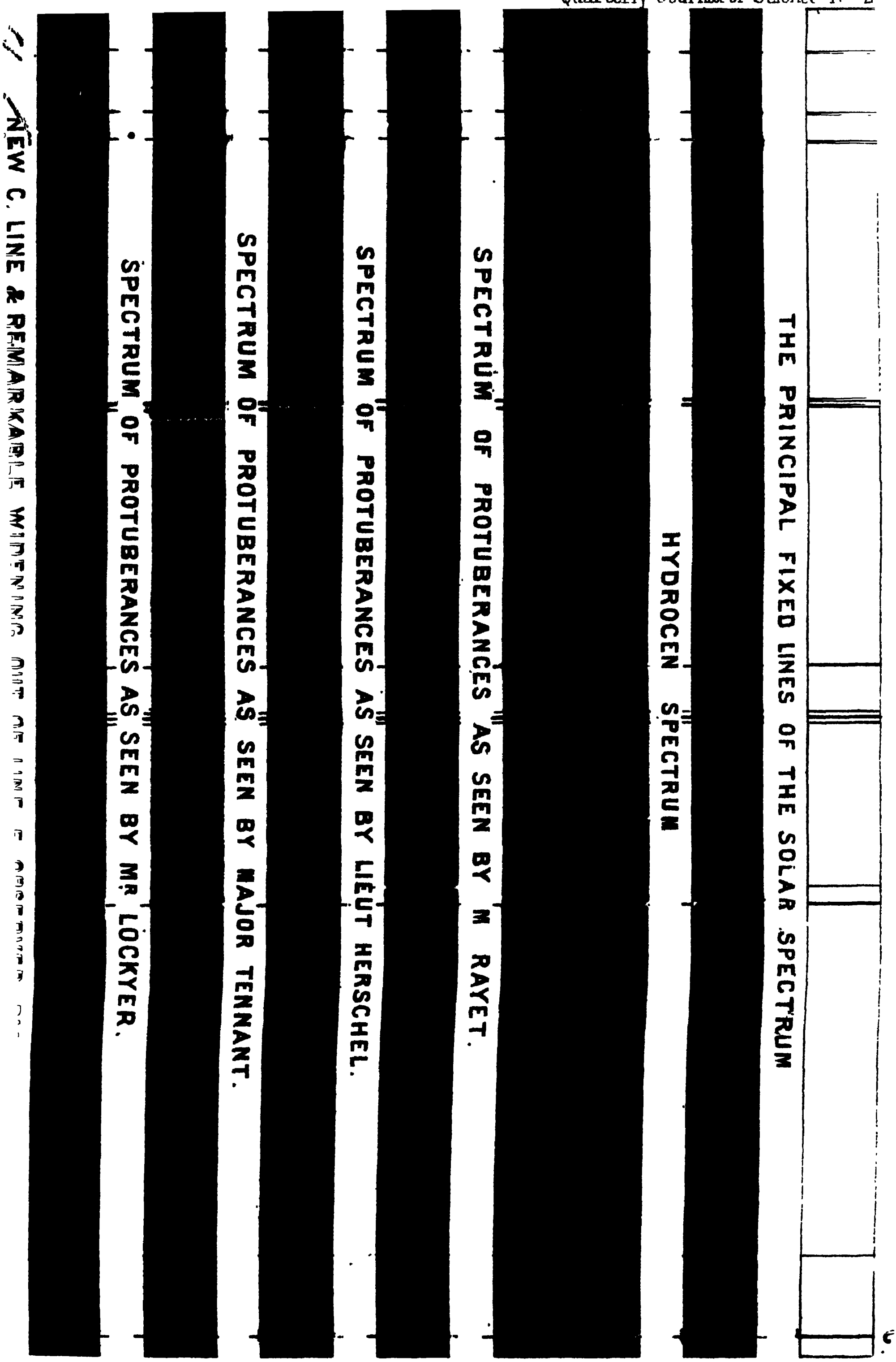
near relative, science-education. It is fairly within the scope of an ardent and timid imagination to conceive that a state might attempt to indoctrinate the national mind with a certain foregone and foredetermined scheme, adapted to work towards some set purpose; but it certainly is not possible to imagine the utter absurdity of a state influencing the direction of discovery, or shaping the perceptions of new truth.

On the whole, then, the investigation which will now be formally entered upon, and which will be pressed upon public attention, will be pretty much compressed into a nutshell, and will take one clear practical issue. At a time when the surface deposits and surface leads of the great mine of theoretical and practical science are almost exhausted by individual pickers, are deep diggings to be opened out by the aid of a small driblet of the capital that has been created from the past yieldings of the property? Are civilized nations, and especially is England, where there is such isolation and concentration of life and mind-energy, to remain content to benefit by small accidental waifs and strays of discovery that fall in from time to time; or is a clear, powerful, and organized effort to be made to use the present accumulation of human intelligence as a means of quickening the acquisition of that thorough knowledge of the properties and workings of material nature, which is the essence of civilization, and the instrument by which the well-being, the high dignity, and the happiness of the human race are worked out?

VI. *THE GREAT SOLAR ECLIPSE OF AUGUST 18, 1868.*

By William Crookes, F.R.S., &c., Editor.

The phenomena attending a total eclipse of the sun have always been of a most impressive character, but only within a comparatively recent period have they been observed systematically, and still more recently looked forward to as an opportunity for solving many important problems in solar physics. Previous to 1860, our knowledge of the physical constitution of the sun was based almost exclusively on theoretical grounds. In that year, however, a somewhat important eclipse of the sun occurred, the line of totality passing over Spain, and expeditions from different countries were organized to observe it. The most important of these was that taken from England by Dr. Warren De la Rue, who especially devoted himself to securing photographic records of the progress of the eclipse. The point on which information was principally sought was the physical constitution of the red protuberances, for



TO ILLUSTRATE ARTICLE ON THE GREAT SOLAR ECLIPSE.

hitherto opinions had been divided as to whether they belonged to the sun, the moon, or were the results of refraction, &c., in our own atmosphere. The highly successful photographs taken by Dr. De la Rue solved this point, and proved conclusively that the prominences belonged to the sun. But these photographs, whilst they solved one point, raised other problems even more perplexing. Assuming that the prominences belonged to the sun, it had been taken for granted that they were of the nature of mountains projecting from the solar disc, but the photograph showed us enormous masses of matter, well defined and sharp in their outline, but of a size and shape perfectly incompatible with solidity, and hanging suspended several thousand miles above the surface of the sun. Instead of being settled by the 1860 eclipse, the problem was in reality only started, and astronomers, chemists, and physicists, have been looking forward eagerly to the opportunities offered last August to advance some steps nearer its solution.

It seems as if a combination of interesting researches in several branches of science culminated in this one eclipse. Simultaneously with the definite statement of the problem by the photographs, the attention of the scientific world was forcibly directed to a new instrument of physical research—the spectroscope—which was destined to afford a complete answer to the main question. The admirable researches of Bunsen and Kirchhoff* led to the general prosecution of spectroscopic research, and paved the way for the discoveries of Kirchhoff, Foucault, Plucker, Miller, Huggins, and others. The researches, especially of the latter philosopher, on the spectra of the stars, nebulæ, and comets, showed what a powerful instrument the spectroscope would be in researches on solar physics, and especially in the examination of those rare phenomena only to be seen during a total eclipse.

It was accordingly agreed tacitly that spectrum observations were those likely to bear most fruit, and in most of the expeditions which were sent out this year the spectroscope was intended to play an important part.

This great eclipse stands alone in the annals of astronomy. In time of duration (nearly seven minutes at the maximum) it exceeds all recorded eclipses, and more than thirty generations of astronomers will come and go before an equal length of totality will be witnessed. The eclipse observed in Spain only gave the observers 3½ minutes as the longest time in which to concentrate their observations, and it is therefore not surprising that so much anxiety was shown amongst scientific men of all countries to make the most of this grand opportunity.

No single astronomical event has ever before excited such

* 'Phil. Mag., August, 1860.

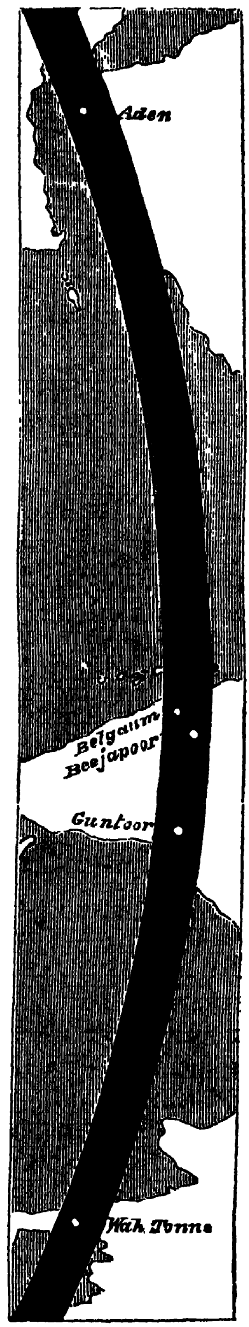
interest. Expeditions were sent half-way across the globe, from England, France, and Germany, and, fitted with all the necessary apparatus, were stationed at different points along the line of totality, from Aden, on the Red Sea, to Wah-Tonne, in the Malay peninsula. Two expeditions were sent from England, one under the auspices of the Royal Society, under Lieut. Herschel, who was to devote himself principally to spectrum observations of the corona and red prominences; the other, from the Royal Astronomical Society, under the charge of Major Tennant. The Royal Society spent nearly 300*l.* for instruments for the expedition; and in case bad weather should interfere with the observations at the principal stations, four hand-spectrum telescopes, similar to those devised by Mr. Huggins for observations of meteors, were also sent out to be distributed to other observers along the central line of the eclipse. The French also sent out two expeditions, one under the charge of M. Janssen, and the other under M. Stephan. Two Prussian expeditions were sent out, and it was also expected that Mr. Pogson, of the Madras Observatory, would also start with a party of observers to some spot along the central line.

Major Tennant, some considerable time beforehand, computed for the whole breadth of the Indian peninsula the central line and the limits of totality. The shadow is about 143 miles broad, and *the line of totality* would pass over Kolapoor, Belgaum, Kurnoul, *Sikunderabad, Ongole, Guntoor, Masulipatam,* Rajah Mandri, the whole course of the *Kistna,* its *Delta,* and that of the Godaveri, and parts of the valleys of the Bhuna and Toongabruda. Leaving India proper, the shadow would cross the Bay of Bengal, the north Andaman island, and then pass through the Mergui Archipelago and the province of Tenasserim, across the Malay peninsula to the island of Borneo, which it would reach between our colony of Labuan and the Sarawak country. "Of this course," Major Tennant considered "the west coast of India would be experiencing the south-west monsoon. The same state of things exists at the Andaman Islands, and on the British side of the Malay peninsula. The other side is not easily attainable, and I am not aware that there would be any inducement to go to Borneo. The Eastern part of the track through India affords, I believe, every chance of fine weather, and I think observers would do well to select that part."

In accordance with these suggestions, the North German Expedition stationed themselves at Aden; Lieut. Herschel went to Belgaum; another English party, under Captain Haig, who had been supplied with one of the hand-spectroscopes, was stationed at Beejapoor; whilst the other English expedition under Major Tennant went to Guntoor, at which station the French observers under M. Janssen, who represented the Académie des Sciences

and the Bureau des Longitudes, also located themselves; lastly, another French observer, M. Stephan, and party, took their post of observation at Wah-Tonne, on the Peninsula of Malacca. Another German expedition stationed at Moolwar, eighteen miles south of Beejapoor, were unfortunately prevented by clouds from making any observations.

Fig. 1.



The Path of the Eclipse—August 18.

Fig. 1 shows the path of the eclipse, the black band covering all places within the line of totality. The different stations are named and left white. Thus the North German observers would secure their results at half-past six in the morning, soon after sunrise, whilst those situated at the more easterly stations would not commence work until several hours later. Most of the expeditions were supplied with photographic apparatus, and it was hoped that by thus securing photographs of the totality, taken at intervals of several hours, it could be ascertained whether the form of the protuberances underwent any perceptible change of shape. The German expedition at Aden and that under Major Tennant at Guntoor were more or less successful in securing photographs, but sufficient time has not yet elapsed to enable any comparative examinations to be made of these.

The principal phenomena which had to be observed (besides the general aspect of the country, the variations in the intensity of light, &c.) were:—

1. Photographic delineations of the phenomena of totality.
2. The position, heights, and general configuration of the red protuberances.
3. The appearance of the corona and its state of polarization.
4. Spectrum observations on the corona and prominences.

These by no means exhaust the list of what was to be observed, but writing after the event, they form convenient headings under which to range the various discoveries. For the sake of convenience, the results of the various expeditions will be collated and described under these several headings.

1. Photographic Results.

Judging from the accounts which have come to England, there appears little doubt that the German expedition to Aden was the most successful in this respect. Dr. Vogel, one of the most eminent of the German photographers, had been selected to take charge of this department. His arrangements were admirable in their systematic precision. Possible cases of failure were anticipated, and carefully provided against, and for some time previously all the staff had been engaged in rehearsing the various operations which would have to be gone through during the eventful $2^m\ 55''$ of totality; in short, everything was so well rehearsed, and every one so carefully told off to his duty, that failure from preventible causes was scarcely possible. Aden had been selected as the most likely spot in the zone of totality to be free from clouds; the evening before the eclipse was, however, very cloudy, and occasioned great anxiety, and on the morning of the 18th the sun rose behind thick banks of *purple gray cloud; before totality commenced the clouds separated*, and enabled four successful photographs to be taken. The apparatus employed was a telescope having an achromatic lens six inches diameter and six feet focus, specially ground by Steinheil, so as to get the photographic image in focus. This afforded a solar image of $\frac{3}{4}$ths of an inch in diameter, and was mounted equatorially and moved by clockwork, adjusted so as to counteract the motion of the earth, and to keep the telescope rigidly fixed on the image during the ten or fifteen seconds required to receive the impression. To the end of the telescope was fixed a small photographic camera, provided with dark slides, each of which would hold a sensitive plate large enough to take two images. The following is the description given by Dr. Vogel of his operations:—

"The totality of the eclipse at Aden was about three minutes long (in India five minutes); nevertheless, we had chosen Aden for our station because there were already photographic observers in India, and because the totality appeared at Aden about an hour earlier than in India. Therefore a comparison of the different results would enable us to decide the question if the protuberances appearing at a total eclipse of the sun were changing in the course of time or not.

"Our task was to get, within these three minutes, as many views of the phenomenon as possible. For this purpose we had previously exercised ourselves in the employment of the photographic telescope, like artillerymen with their guns. Dr. Fritsche prepared the plates in the first tent, Dr. Zenker put the dark slides into the telescope, Dr. Thiell exposed, and I myself developed in the second tent. We ascertained that it was possible in this way to get six images (three plates of two images) during three minutes.

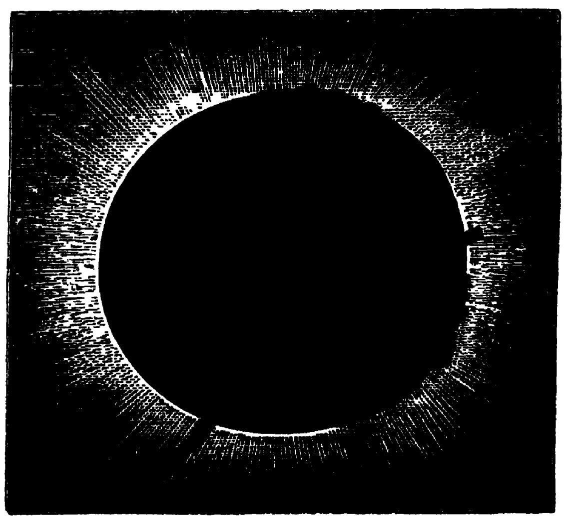
"When the decisive moment was fast advancing, the sky, hitherto covered with clouds, showed some openings, through which the sun, already covered partially by the moon, was to be seen.

"The sun crescent became smaller and smaller, and the opening in the clouds seemed to increase.

"The last minutes before the totality (which began at twenty minutes past six o'clock) went rapidly away. Dr. Fritsche and myself crept into the tents, where we remained, consequently we have seen nothing of the totality. Our work began; we exposed the first plate five and ten seconds, in order to know what was the proper time.

"Muhammed, our black servant, brought the first attempt into my tent. I poured the iron developer over the plate, eager to know what was to come. At this moment my light was extinguished. I called for light, but nobody heard me, as all were about their task. I stretched my right hand out of the tent, holding the dark slide in the left, and happily caught a small oil lamp, which I had previously prepared. And now I saw the image of the sun appearing on the plate. The dark margin of the sun was surrounded by a series of peculiar elevations—the other side showed a strange hook; the phenomenon being exactly the same in both views. My joy was great; but there was no time for enjoyment. I soon received the second, and, after another minute, the third plate. 'The sun is coming forth!' exclaimed Dr. Zenker. The totality was over. All seemed to have been done in a moment.

Fig. 2.



"When I developed the second plate I perceived only very weak traces of an image. The clouds had veiled the sun at the very moment of the exposure. The third plate gave two brilliant views, with protuberances at the lower margin. Glad to have secured so much, we washed, fixed, and varnished the plates, and immediately took some copies on glass, which were to be dispatched to Europe separately."

Fig. 2 is copied from these photographs.

The protuberances *a*, *b*, and *c* were given on the first plates, and

the protuberances *d*, *e* were shown on the third plate. The great horn *e* is in height about $\frac{1}{14}$th of the sun's diameter, and it would therefore in reality be 12,000 miles high.

Major Tennant, writing from Guntoor, on the day of the eclipse, says:—

"This morning was very promising, and if it had followed the course of its predecessor we should have had a magnificent clear sky, but it clouded over the east with thin cumulostrati, which, while hardly stopping vision, interfere very much with the photographic energy; and the result was that every negative was under-exposed, and we have little more than very dense marks showing the protuberances. The six plates arranged for were duly exposed, but the heat so concentrated the nitrate of silver solution that, besides showing but faint traces of any corona, they are all covered with spots. Still, we may make something of them, and will try."

This appears very unsatisfactory; but from a second letter, written five days after, he says that they have since been enlarging the photographs, and he is very well satisfied.

"The clouds reduced the actinism very much and very unequally, but that has shown new things to me. 1st. There is very little corona. 2nd. The cloudy structure of prominences is very marked. But the most remarkable thing is a great horn, which seems to have been 3′ 20″ nearly high. I have, as I told Mr. Airy, clearly seen in its spectrum, C, D, and *b*, and I believe I saw F, but did not identify it. Now this shows both in Nos. 1 and 3 (photographs) as a ribbon of light, coiled spirally round a semi-transparent centre. It is very beautiful, and marked in 3, which was taken two minutes after the (commencement of) totality, and I am doing my best to keep this feature (to retain this feature) in the copies. No. 1 was taken apparently before the last of the sun went. Phillips (one of his assistants) says it was; and there is a spot of fog such as would be the result. There is a fine line of light seen through all this fog much brighter than the corona. This, too, I am keeping on enlarging. We have got six enlarged positives about 2½ inches in diameter from each negative. Every one of these shows the same remarkable spiral structure in the great horn. I find there are traces in a drawing which Dr. Janssen got made of that prominence (mentioned in the first part of his letters as invisible to the eye) of which I spoke. The positive copies I will enlarge to 9 inches."

In a subsequent letter Major Tennant says that the great horn was 90,000 English miles or more in height.

The editor of the 'Photographic News' has commented in very severe terms on these results. He says:—"Our first impulse, on reading such a statement as the result of such an expedition on

such an occasion, was to repeat the famous sentence of Ruskin, 'This is not failure, but disaster!' Compared with the results obtained by Mr. Warren De la Rue in Spain, in 1860, compared with those secured by the German Expedition, such an issue as the above is most humiliating. The plates were under-exposed, and covered with spots, we are told, as though the possibility of guarding against such contingencies was a thing undreamt of. This expedition was sent out by the Royal Society, aided by Government, and we fear very much that it is to the aid of the latter much of the failure may be attributed. It is probable, in fact, that it is due to red tape. A staff of men provided by Government might or might not be fitted in all respects for the work; but if the men 'told off' for the duty knew nothing of photography, it would be against all precedent to import a photographer from another department. If the men were selected from the Engineers, and they were not familiar with photographic operations, it would be quite inadmissible to introduce amongst them men from (say) the Artillery, who were skilled photographers. It is probable, from what we can learn, that to a cause of this kind the failure in result was due. Be this as it may, however, it appears tolerably clear that no experienced photographer formed part of the expedition staff, or we should not have heard of such puerile difficulties as spots from concentrations of the silver solution. We have in this country several photographers of high repute and great practical skill, who have had experience in Eastern photography, and who have succeeded amid the gravest difficulties. We refer to such men as Bedford, and Frith, and Goode. Surely it would have been possible to have secured the services of some of these or other experienced photographers to whom the purely photographic operations should have been confided, and who would have certainly secured immunity from the disasters attending concentrated silver solutions, and probably also from the risk of under-exposure."

2. The general Configuration of the Red Protuberances.

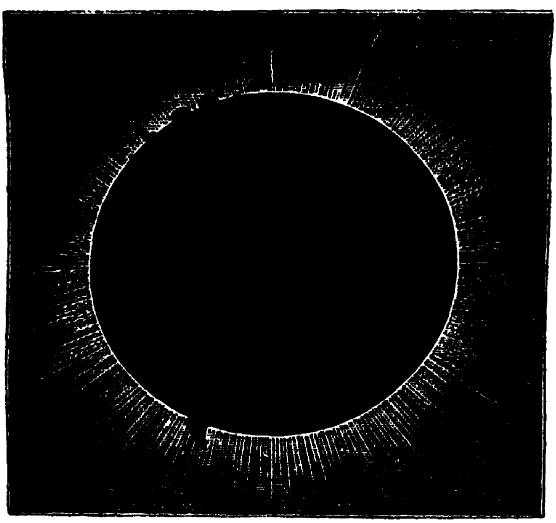
On this subject an immense amount of information has been accumulated. At Aden Dr. Weiss says that three protuberances were visible during the eclipse, without counting the red border which at the commencement and at the end of the totality encircled wide portions of the lunar limb, and which towards the end appeared surrounded by a deep blue aureola shading off into the sky. The first protuberance appeared very near the point where the last ray of the sun disappeared. Its appearance was that of an agglomeration of protuberances very complicated in its details. The second, the most interesting of all, was located at the eastern

border of the lunar disc, rising to a considerable height almost perpendicularly. Its appearance was nearly that of a finger bent in the middle. The third only appeared towards the end of totality in the form of a small conical elevation almost diametrically opposite the first. All these protuberances were of a clear carmine tint and sharply defined.

Dr. T. Oppolzer, one of the observers at Aden, reports that the prominences appeared as if detached from the sun. At the final moment of totality, there was noticed at the spot where the sun was about to reappear, a red border, separated at the last moment from the lunar disc by an intensely luminous space, which formed, as it were, a bridge between the disc and the red border.

Captain Tanner, R.E., who in conjunction with Captain Haig and Mr. Kero Laxuman, observed the eclipse at Beejapoor, has given the following account of his observations. This gentleman is an *expert delineator, and occupied himself in making rapid sketches of what he saw.* The accompanying drawing (Fig. 3) is copied from Captain Tanner's sketch, who gives the following description of it:—"I at first saw three prominences—one long, curved, pointed tongue, and two close together, straight but flat-topped, about two-thirds the height of the former. They were of a rose-madder colour, and were decidedly more like flames than anything else, not only in their general appearance and colour, but by their being composed of smaller tongues of flame parallel (or nearly so) to the general axis of the flame, so that they had a streaky appearance and a ragged edge. At the first glance, when the sun was somewhat obscured by clouds, I thought they were homogeneous and had hard edges; but this idea was at once dispelled when the clouds cleared off. The two protuberances, which were close together, were not, as far as I could see, joined by any smaller shots of flame. I afterwards observed one small protuberance, and marked the position of it in my sketch. I did not observe that it was streaky, as the others were—perhaps on account of its being so small, and perhaps because I had not sufficient time to examine it properly. As regards the corona

FIG. 3.

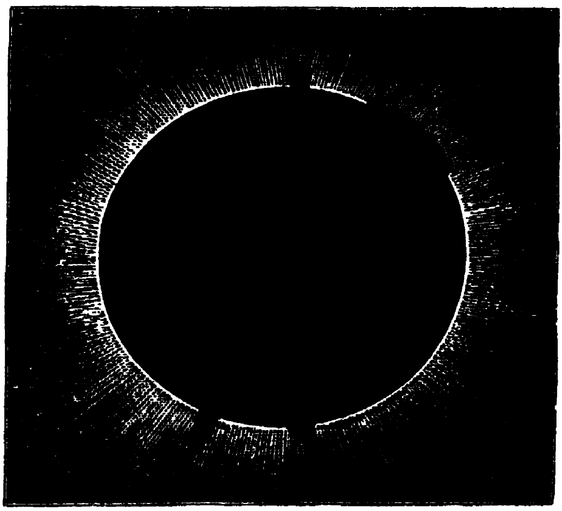


when we first began to see the eclipse through the clouds, I was under the impression that the eclipse, instead of being total, was only annular, so bright was the corona near the moon's limb. I could not detect any irregularities in the structure of the corona, but the light appeared to be gradually shaded off all round."

Dr. Janssen, who was at Guntoor, was principally occupied with spectrum observations, but he gives a very graphic account of the appearance of the long horn, which he says was more than three minutes high, and shone with a splendour difficult to imagine. It recalled the flame of a forge issuing with violence from openings in the fuel, and driven by the force of the blast. The protuberance on the right (the eastern edge) presented the appearance of a collection of snowy mountains, whose base rested on the limb of the moon, and which were illuminated by a setting sun.

The ordinary observations at Wah-Tonne on the protuberances were made by M. Stephan. He examined the phenomena of totality in a large telescope, and describes the protuberances as appearing with marvellous sharpness: they were in four groups, arranged as shown in Fig. 4; their colour was described as rose coral, slightly tinged with violet; they all seemed attached by a perfectly distinct base, and not to float at a certain distance above the sun, as drawn by some observers in recent eclipses. The longest protuberance had a length which was not less than the tenth part of the lunar diameter.

Fig. 4.



During this eclipse it was noticed by more than one observer that the red flames were not extinguished immediately after the totality had passed over. Thus Dr. Weiss, at Aden, said that the large horn remained visible for a minute after the sun had reappeared, being only then lost in the clouds; and Dr. Oppolzer, who was also at Aden, says that this same protuberance could be distinguished for thirty-seven seconds after the last moment of totality. At Beejapoor, Mr. Kero Laxuman describes the great protuberance as like a red flaming torch, streaked by several dark red lines. He says it was visible "for about two minutes after the end of totality, and had there been no clouds I think it

could have been seen longer. At Wah-Tonne, M. Stephan records that one of the protuberances remained visible for several seconds after the third contact (the reappearance of the sun). This persistence may seem extraordinary, since the long protuberance did not appear till the second contact; this, however, may be attributed to the fact, that at the third contact the eye was in a state of repose owing to the darkness of totality."

Another curious phenomenon has been recorded by some observers, from which it would appear that close to the surface of the sun there is a highly luminous atmosphere. This is most strikingly described by M. Stephan. He says that the second contact was not followed by a sudden disappearance of all bright light; after the disappearance of the edge of the sun the moon still appeared to M. Tisseraud and himself as if it were surrounded with a narrow luminous border, about a quarter of a minute in thickness, of a brilliancy almost comparable to that of the sun: "this ring is so brilliant that it might lead to an error in the estimation of contact. This luminous ring reappeared some seconds before the third contact. Thus, the actual globe of the sun would appear to be surrounded with a thin diaphanous shell, extremely brilliant."

The captain and officers of the 'Rangoon,' steamship, belonging to the Peninsular and Oriental Steamship Company, which happened to be almost on the central line of totality, have given a very full description, with drawings, of the phenomena observed.

Fig. 5.

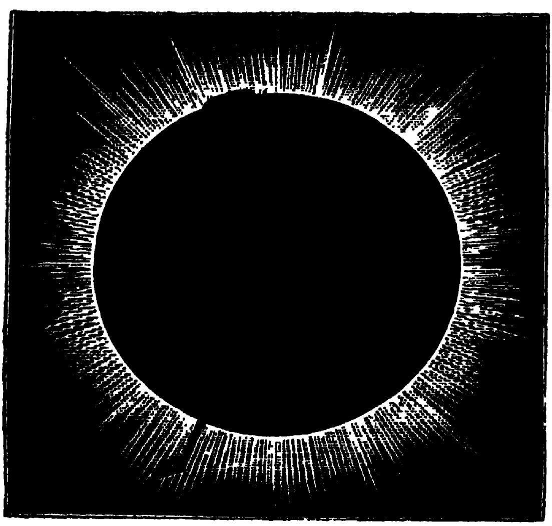


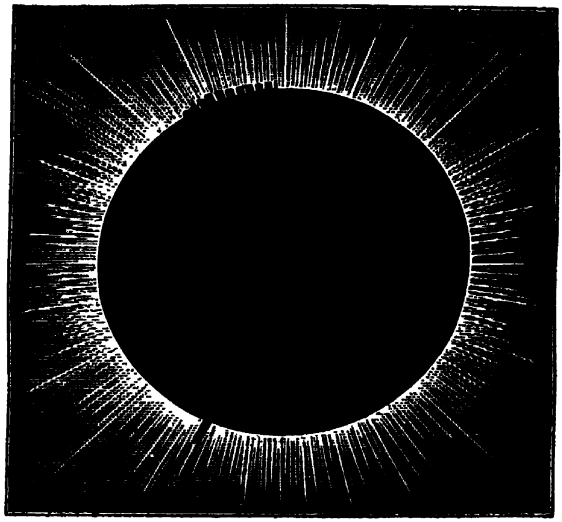
Fig. 5 shows the appearance presented to them soon after the commencement of totality. The long flame was 5′ high, and very brilliant; in the upper portion was another shorter and wider prominence. One of the officers on board says that the long horn became suddenly visible about a minute after the commencement of totality.

Fig. 6 shows the position of the prominences at the reappearance of the sun. The upper prominence disappeared suddenly, but the inferior one remained visible for about ten seconds longer, with its dimensions reduced one-half.

The colour of the prominences is described as different by each observer.

Major Tennant describes them as white; Captain Branfill, as coloured; Captain Haig speaks of them as "red flames;" Captain Tanner, as rose madder; Mr. Kero Laxuman, as a red flaming torch, and as red streaked by several darkened lines. Governor Hennessy compares one of them to a tower of rose-coloured clouds, "more beautiful than any rose-colour I ever saw;" another he describes as a bright blue, like a brilliant sapphire with light thrown upon it; next to that was the so-called rose-colour, and at the right corner a sparkling ruby tint.

FIG. 6.



3. The Phenomena of the Corona.

The state of polarization of the light of the corona was the principal phenomenon which was to be observed, and the results are very concordant.

Lieut. W. M. Campbell, who was stationed at Belgaum with Lieut. Herschel, determined satisfactorily that the light of the corona was polarized in planes passing through the sun's centre. Captain Branfill, who was at Guntoor, made the same observation, and this fact has been further confirmed by the observations made by the French observers.

The accounts received as to the luminosity of the corona vary. Captains Haig and Tanner say that on the first glimpse of the eclipse the corona appeared so bright that it gave them the momentary impression of its being an annular eclipse; and Captain Haig further remarks that the light of the red flames was to the naked eye so feeble as to be outshone to extinction by that of the corona. Governor Hennessy, in the Island of Borneo, speaks of the corona as a luminous ring, composed of a multitude of rays quite irregular in length and in direction; from the upper and lower parts they extended in bands to a distance more than twice the diameter of the sun. Other bands appeared to fall towards one side; but in this there was no regularity, for bands near them

fell away apparently towards the other side; they resembled masses of luminous hair in complete disorder; and Lieut. Ray compared them to horses' tails.

Very few spectrum observations were made of the corona, but it apparently gave either no spectrum at all or a very faint continuous spectrum; no bright lines were seen. What few observations appear of value will be found under the next section, as the observations of the corona and the red prominences cannot easily be separated.

It is interesting to observe how the darkness appeared to vary in different places during totality. Captain Haig, near Beejapoor, says that they were surprised to find it so far from total: they could easily write, read writing, and read the seconds of their watches, without the aid of artificial light; in the town, on the contrary, the darkness was so great that it was not possible to see one's own hand; and at Moolwar a gentleman dropped part of an eye-piece of a telescope, and it was not possible to find it, even by placing the eye close to the ground, until after the end of totality. In Borneo, under a cloudless sky, the darkness came on as if a thunderstorm was just about to break: the birds, dragonflies, and butterflies disappeared, and the crickets and cicadæ began to sound; and immediately before the total obscuration the horizon could not be seen; the sky was of a dark leaden blue, and the trees looked almost black; the faces of the observers looked dark, but not pallid or unnatural. The moment of maximum darkness seemed to be immediately before the total obscuration, and for a few seconds nothing could be seen except objects quite close to the observers. Major Tennant says that the darkness was very slight, and the colour not half so gloomy as in the eclipse of 1857, which was partial at Delhi, where he was then.

Venus shone out very brilliantly, and Sirius and several other of the brighter stars were seen, but no mention is made by anyone of Mercury or the supposed intra-mercurial planet Vulcan.

4. Spectrum Observations on the Corona and Red Prominences.

Most fortunately, these observations, which were likely to be of the greatest importance, have been the most uniformly successful. The least satisfactory observation is that of M. J. Rziha, one of the North-German party at Aden; but from the description of the apparatus it was not well fitted for the examination of any special part, and would only give a general spectrum of the whole light received on it. He says that his object was to concentrate on the spectrum the light emanating from the corona during the totality The black lines of the solar spectrum remained perfectly distinct

till the commencement of totality, when they disappeared immediately, leaving only a dull spectrum, still always perceptible and continuous. A reversal of the spectrum, that is to say, an appearance of luminous lines in the places occupied by the black lines did not take place. When towards the end of totality, light clouds covered the corona in such a manner as only to allow the light from the red border and that from the protuberances to pass, the spectrum underwent a remarkable change, all the colours of greater refrangibility than the green disappeared, and the red extremity only remained under the form of a spectrum interrupted by wide bands. The first ray of the sun after totality instantly occasioned the reappearance of Fraünhofer's lines.

Amongst the English observers Lieut. Herschel took the most accurate observations. In a letter to Mr. Huggins, dated from Belgaum, he gives the following vivid account of his discovery of the constitution of the red flames:—

"About a quarter of a minute before totality a thick cloud obscured the sun. I had placed the slit of the spectroscope so as to cross the crescent at about the vanishing point of the limb, and was watching the narrow solar spectrum grow rapidly narrower. You may conceive the state of nervous tension at this moment. Whatever the corona was competent to show must in a few seconds have been revealed—unless indeed it should so happen that a prominence should be situated at that precise spot, in which case the double spectrum would be presented. But the solar spectrum faded out while it had still appreciable width, and I knew a cloud was the cause. I went to the finder, removed the dark glass, and waited—in that fever of philosophical impatience which recognizes the futility of irritation, even while it chafes under the knowledge of fleeting seconds—how long I cannot say, perhaps half-a-minute. I can well recall the kind of frenzied temptation to turn screws and look somewhere else, checked by the calm ticking of the clock telling of a firm hold of the right place, cloud or no cloud. Soon the cloud hurried over, following the moon's direction, and therefore revealing first the upper limb, with its radiating and, as I fancied, scintillating corona, and then the lower limb. Instantly I marked a prominence near the needle point in the finder. A rapid turn of the tangent screw covered it with the point of the needle. Those few seconds of unveiling were practically all that I saw of the eclipse as a spectator. The instant the prominence was under the needle point I returned to the spectroscope. A single glance solved the problem in great measure. Three vivid lines—red, orange, blue! No others, no trace of a continuous spectrum. I think I was a little excited about this time, for I shouted quite unnecessarily to my recorder, 'Red, green, yellow,' quite conscious of the fact that I meant orange and blue. I lost no time in applying

myself to measurement. And here I hesitate; I have no idea how those five minutes passed so quickly. Clouds were evidently passing continually, for the lines were only visible occasionally. The red must have been less vivid than the orange, for after a short attempt to measure it I passed on to secure the orange, and succeeding to my satisfaction, tried for the blue line. Here I was less successful. The glimpses of light were rarer and feebler, the line itself growing shorter and farther from the cross. I did, however, place the cross very near the true position, and got a reading just as the re-illumination of the field of view informed me that the sun had reappeared on the other limb. I consider there can be no question that the orange line was identical with D (sodium), so far, at least, as the instrument is competent to establish an identity. I also consider that the identity of the blue line with F (hydrogen) is not established; on the contrary, I believe the former is less refracted than F, but not much. With respect to the red line, I hesitate much in assigning an approximate place. It might have been near C (hydrogen). I doubt its being so far as B, but there would be its limits. The corona may have projected a spectrum of some kind, but I saw none."

The observations made by Captain Haig were of less value than those of Lieut. Herschel, being taken with a hand-spectroscope which he had fitted to a small telescope. He reports that he observed the spectra of two red flames close to each other, and in their spectra two broad bright bands quite sharply defined, one rose-madder and the other light golden. Just before emergence, these spectra were soon lost in the spectrum of the moon's edge, which had also two well-defined bright bands (one green and one indigo) about a quarter of the width of the bands in the spectra of the flames, this spectrum being again soon lost in the bright sunlight.

Major Tennant, at Guntoor, was more successful, owing doubtless to his apparatus being more perfect. He reports a continuous spectrum from the corona, and one of bright lines from the prominences examined. He says:—"I am, I believe, safe in saying that three of the lines in the spectrum of the protuberances correspond to C, D, and *b*. I saw a line in the green near F, but I had lost so much time in finding the protuberance (owing to the finder having changed its adjustment since last night), that I lost it in the sunlight before measuring it, and I believe I saw traces of a line in the blue near G, but to see them very clearly involves a very large change in the focus of the telescope, which was out of the question then. "I conclude that my result is that the atmosphere of the sun is mainly of non-luminous (or faintly luminous) gas at a short distance from the limb of the sun. It may have had faintly luminous lines, but I had to open the jaws a good deal to get what I could

see at first, and consequently the lines would be diffused somewhat; still I think I should have seen them. The prominence I examined was a very high narrow one, almost, to my eye, like a bit of the sun through a chink in brightness and colour (I could see no tinge of colour), and somewhat zigzagged, like a flash of lightning. It must have been three minutes high, for it was on the preceding side of the sun near the vertex, and was a marked object, both in the last photo-plate just before the sun reappeared, and to the eye."

The French observers seem to have been very successful. M. Janssen, who was furnished with spectrum apparatus of a perfect description, describes the phenomena in the following manner:— "Soon the disc of the sun appeared reduced to a thin luminous crescent. Our attention was redoubled. The jaws of the spectrum apparatus attached to the six-inch telescope were rigorously kept in contact with that portion of the lunar limb which was about to extinguish the last rays of the sun, so that the slit would be led by the moon herself into the lowest regions of the solar atmosphere when the two discs were tangent. The light disappeared all at once, and the spectral phenomena changed at the same time in a very remarkable manner. Two spectra, formed of five or six very brilliant lines, red, yellow, green, blue, violet, occupied the field of view, replacing the solar spectrum which had just disappeared. These spectra, about a minute in height, corresponded ray for ray, and were separated by a black interval, in which I could distinguish no appearance of a brilliant line. The finder showed that these two spectra were due to two magnificent protuberances which shone out to the right and to the left of the line of contact where extinction had just taken place. The preceding observation shows directly:—

"1. The gaseous nature of the protuberances (brilliant spectral rays).

"2. The general similitude of their chemical composition (the spectra corresponding ray for ray).

"3. Their chemical nature (the red and blue rays of their spectra were decidedly C and F of the solar spectrum, characteristic as is known of hydrogen gas)."

The observing party at Wah-Tonne appeared to have been even more successful than M. Janssen, if we may judge from the number of lines seen and identified. M. Rayet had charge of the spectrum apparatus, which consisted of a telescope with a silvered glass mirror 20 centimetres in diameter, mounted equatorially for the latitude of the station, and of a direct vision spectroscope. The latter instru-

ment, formed of three very dispersing prisms, was arranged of short length, and to give much light.

The slit of the spectroscope having been arranged so as to cut at right angles the image of the narrow luminous arc which would remain some seconds before total obscurity, the light from the extremity of the horns was first examined. On the ground of a spectrum with very sharp black lines formed by the diffused atmospherical light was seen a much more luminous band, which was the spectrum of the light emitted by the extremity of the horn. Whatever was the width of this part, nothing particular could be noticed in it; the rays had an appearance in respect to width and intensity identical with those of the ordinary solar spectrum.

The observation of the horns was interrupted some seconds before totality, in order to remove the diaphragms from the telescope, to slightly open the slit of the spectroscope, and thus be prepared to examine the protuberances.

At the instant of total obscurity, the slit of the spectroscope having been brought on to the image of the long protuberance, which became visible on the eastern edge of the sun, M. Rayet immediately saw a series of nine brilliant lines, which, by their arrangement in the field, their relative distance, their colour, and their general effect as a whole, appeared to be related to the principal lines of the solar spectrum—B, D, E, *b*, an unknown line, F, and two lines of the group, G. These lines possessed great brilliancy, and appeared strongly relieved from the ashy grey very pale ground.

During these observations, the slit of the spectroscope was parallel to the principal length of the protuberance. Thus the luminous lines were seen in the apparatus of a length in proportion to the height of the protuberance; the slit having been turned 90° round, the rays appeared reduced to the appearance of brilliant points corresponding to the slight width of the luminous horn; no error of observation is therefore possible, and the brilliant lines actually represent the spectrum of the light of the protuberances.

The spectroscope being in the first position (the slit parallel to the length of the protuberance) the very brilliant lines corresponding to D, E, and F, were seen to be prolonged beyond the mean length, by a very feeble luminous tract, the spectrum presenting the appearance given in the coloured diagram. A certain portion of the incandescent gaseous light which forms the protuberances therefore spreads into the solar atmosphere beyond the limits which the eye in general assigns to these expansions.

The examination of this first protuberance being finished, the slit was directed to the large luminous region at the west of the sun. This time, also, the spectrum was seen to consist of brilliant lines arranged as in the first case, with the exception of there being

only one violet line. Therefore all the protuberances do not appear to emit identical light.

It was remarked that the light at the corona was very faint in comparison with that of the protuberances; for whilst the light of the latter gave a very vivid spectrum, the corona, in spite of the rather large opening of the slit, did not give any appreciably coloured spectrum.

In the coloured lithograph which accompanied this article, the artist has endeavoured to reproduce as closely as possible the various spectra observed at the different stations. The upper plain one gives the positions of the principal fixed lines in the solar spectrum, the second spectrum consisting of three coloured lines on a black ground, represents the spectrum of incandescent hydrogen. Below that will be seen the lines observed by M. Rayet, with the faint prolongations of E, F, and G spoken of above. The one below that represents the spectrum seen by Lieut. Herschel, and that observed by Major Tennant follows. When this plate was prepared, no detailed description of Janssen's spectrum had been received, except that the lines seen were principally those of hydrogen. The two lower spectra will be referred to immediately.

We come now to a very remarkable double discovery which inaugurates a field of investigation, destined to produce a rich harvest of discovery in solar physics. Two years ago, Mr. Norman Lockyer communicated to the Royal Society a paper, in which he showed how the spectroscope could be employed to decide the claims of two theories as to the cause of sun-spots; and in the concluding paragraph he remarked:*—"May not the spectroscope afford us evidence of the existence of the red flames which total eclipses have revealed to us in the sun's atmosphere; although they escape all other methods of observation at other times? And if so, may we not learn something from this of the recent outburst of the star in Corona?" This was not a chance suggestion, for Mr. Lockyer had been engaged in sweeping round the sun's edge and over its disc with his spectrum apparatus, in the hopes of detecting such a spectrum revelation, but owing to imperfect apparatus no result was for a long time obtained. Another observer, Mr. Stone, met with no better success; and Mr. Huggins, as late as May, 1868, had unsuccessfully put the same idea to the test of experiment. The train of reasoning is sufficiently obvious: the spectroscope alters the relative brilliancy of two spectra, one of which consists of a few isolated luminous rays, the other being continuous from red to violet. The light of the continuous spectrum may be fanned out by a system of prisms, so as to weaken the rays to any

* 'Proceedings of the Royal Society,' Oct., 11, 1866, vol. xv., p. 256.

desired extent by distribution over a large area, whereas the same amount of dispersion merely places the luminous bands of the former spectrum farther apart, without weakening them to any extent. If therefore the red flames gave a spectrum of bright lines, they would become visible by examination under sufficient dispersive power. Mr. Lockyer, satisfied that his want of success was owing to deficient power or want of adjustment in his instrument, *applied himself to construct a more powerful spectroscope,* which was completed in October last. With this he was soon rewarded by the sight of a prominence spectrum, an account of which was forwarded to the Royal Society, on October 20th, in the following words:—" I have this morning perfectly succeeded in obtaining and observing part of the spectrum of a solar prominence. As a result I have established the existence of three bright lines in the following positions:—

I. Absolutely coincident with C.
II. Nearly coincident with F.
III. Near D.

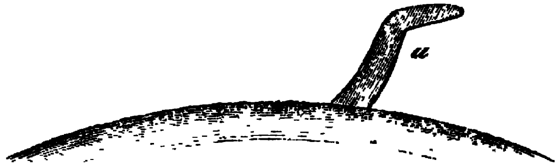
" The third line (the one near D) is more refrangible than the more refrangible of the two darkest lines, by eight or nine degrees of Kirchhoff's scale."

In a subsequent communication to Dr. De la Rue, Mr. Lockyer says that he has been able to recognize that the protuberances are simply local accumulations of a gaseous envelope, which completely surrounds the sun, for in all parts of the circumference he perceives the characteristic spectrum of the protuberances. The thickness of this new envelope is said to be nearly 5000 miles, and it is marvelously regular in its contour, at the pole as at the equator. A prominence gives a spectrum consisting of a few long bright lines, but on directing the instrument to the extreme edge of the sun, and with the slit perpendicular to its tangent, a narrow belt of the true solar spectrum is seen, fringed with that of the new envelope, consisting of a few very short bright lines projected on a very faint continuous spectrum of diffused daylight. The bright lines being superposed on or forming a prolongation of the solar spectrum, it is easy to ascertain with great accuracy whether they coincide with any of Fraünhofer's lines; the dark line sometimes being obliterated and at other times being prolonged by the bright one. If the instrument adjusted in this manner to the extreme edge of the sun be now gradually swept round the circle, when a prominence is reached the narrow spectrum of the chromosphere, as Mr. Lockyer has termed his new solar envelope, begins to lengthen, and by measuring the length of the luminous lines in different parts of the circle, it is easy to map out the shape and position of

the red flames almost as accurately as if the observer had the benefit of a perpetual eclipse.

In this manner Mr. Lockyer has sketched the protuberance shown in the following figure:—

Fig. 7.



When the slit is adjusted so as to fall on *a*, the brilliant rays are seen entirely separated from the solar spectrum.

We come now to the curious duplex nature of this discovery. In describing his spectrum observations of the eclipse prominences of the 18th August last, M. Janssen said:—

"The most important result of these observations is the discovery of a method of which the principle was conceived during the eclipse itself, and which will allow of the study of protuberances and of the regions surrounding the sun at all times, without its being necessary to have recourse to the interposition of an opaque body before the sun's disc. This method is founded upon the spectral properties of the light of the protuberances—light which resolves itself into a small number of very luminous pencils, corresponding to the obscure rays of the solar spectrum."

M. Janssen describes his discovery in the following words:— "It struck me immediately that it would be possible to see the rays without an eclipse. During the night the method and means of execution were clearly arranged in my mind. The next morning, the 19th, the sun rose very brightly. By means of the finder attached to the large telescope, I placed the slit of the spectroscope in part on the solar disc, and part beyond; the slit therefore gave two spectra, that of the sun, and that of the region of the protuberances. The brilliancy of the solar spectrum was a great difficulty, I therefore turned the apparatus so as to remove from the field the red, green, and blue, the most brilliant portions of the solar spectrum. All my attention was directed to the line C which was dark in the sun's spectrum, but brilliant in that of the protuberance. Suddenly I perceived a small brilliant red ray, one or two minutes in height, forming a rigorous prolongation of the black line C of the solar spectrum. Upon moving the slit of the spectroscope in such a manner as to sweep methodically the region that I was examining, this line was persistent, but it became modified in length and in the brilliancy of its various parts, thus showing

great variations in the height and luminous power of the different regions of the protuberance. Shortly afterwards I perceived that the brilliant ray F was visible as well as G. In the afternoon I returned to the region examined in the morning; the brilliant lines showed that great changes had taken place in the distribution of the matter of the protuberances; the lines were sometimes broken into isolated parts which were not united with the principal line in spite of the movements of the exploring slit. This fact indicated the existence of isolated clouds which had been formed during the morning."

The conclusion of M. Janssen's report contains two interesting facts, the first is that the lines of the protuberances penetrate into the black lines of the solar spectrum, thus demonstrating the prolongation of the protuberances on to the globe of the sun. The second is that the protuberances become altered in shape and displaced with extreme rapidity. On the 4th of September a remarkable observation is recorded, showing that a mass of matter many hundred times larger than the earth is in a few moments displaced and completely altered in form.

This discovery of M. Janssen's was strangely enough communicated to the French Academy only a few minutes after Dr. De la Rue had communicated Mr. Lockyer's discovery to the same body; it had before been communicated to the Royal Society. As Mr. Balfour Stewart remarks:—"Although the priority of observation is due to M. Janssen, yet the possibility of the discovery was suggested by Mr. Lockyer more than two years ago, and to my knowledge he has been working at it since that time; whereas M. Janssen frankly acknowledges that the idea only occurred to him during the eclipse itself. This fact was very nobly referred to by M. Faye, at the discussion which followed the announcement of the discovery at the Academy of Sciences."

It would appear as if these luminous lines were somewhat variable in their appearance, some being present in one protuberance and not in others. The temperature and intensity of action going on over the sun's surface have also much to do with their appearance; thus Mr. Lockyer has occasionally detected a new C line, a little less refrangible than C by the distance apart of the two D lines, apparently caused by an ejection of extraneous matter. A curious phenomenon has also occasionally been observed with the F line, it sometimes exhibits a widening at the base or in some other portion of its length, suggesting the explanation that with great increase of temperature the ray of light of this refrangibility becomes nebulous and capable of spreading sideways, in the same way as the yellow sodium lines will do. No other line has been observed to do this.

In the coloured illustration the lowest spectrum shows Mr.

Lockyer's new C line and the abnormal appearance of F. The one above it shows the general appearance of his prominence spectra.

This discovery is being actively followed up, and the Rev. Father Secchi has already communicated to the French Academy two papers on the subject in which Mr. Lockyer's discoveries are in every respect confirmed.

In the absence of detailed official statements from the principal observers, it is difficult to sum up accurately the results of these spectrum observations, although there is no doubt that the scientific gains have been immense. All except Captain Haig directed their spectroscopes to the long horn which forms so prominent an object in all the diagrams given, and which appears to have been connected with one of the solar spots. Major Tennant speaks of it as a vast flame of incandescent hydrogen, magnesium, and sodium vapour, and considering that all the lines of these elements were seen by one or other of the observers during the eclipse, and that Mr. Lockyer and Father Secchi have since proved the presence of the hydrogen lines, there is little doubt that these three elements—hydrogen, sodium, and magnesium—actually do exist in a gaseous and incandescent state in the circumsolar atmosphere.

Since the discovery that the red flames (as we are entitled to call them now) can be examined at any time the sun is visible, the extreme interest with which physicists have hitherto looked forward to a total eclipse will be somewhat abated. It may, however, be worth recording that, on the 7th August next, there will be a total eclipse of the sun visible in North America. The path of totality, about one hundred miles in width, will pass through Alaska, lat. 60° 46·9′ north, long. 68° 4·6′ west of Washington, on Saturday noon; crossing British America, it will again enter the United States territory near the head of Milk River, long. 30° W., pass through the south-west corner of Minnesota, crossing the Mississippi river near Burlington, Iowa, the state of Illinois just north of Springfield, and the Ohio river near Louisville. From thence it will run, in a south-easterly direction, through the states of Kentucky and North Carolina, and reach the Atlantic Ocean near Beaufort, North Carolina, at about sunset. North and south of this line the eclipse will be partial throughout the United States.

The American photographers are already organizing arrangements to bring every available telescope into use on that occasion for photographic purposes, and intend securing photographs along as many points of the path as possible.

The writer, who has already had some experience in photographing the phenomena of eclipses, the moon and sun, would venture to make three suggestions in this respect. Firstly, that attention should not exclusively be confined to the wet collodion process, but that the daguerreotype and dry albumen process should

also be used. Pictures by these processes possess more sharpness, and are capable of giving more microscopic detail, than ordinary wet collodion; moreover, the plates may be prepared the night before and developed after the eclipse is over, thus leaving the operator's whole attention free to devote to the exposure of as many plates as possible.

Secondly, some telescopes should have a system of lenses beyond the principal focus of the object-glass, so as to project a magnified image of the phenomena on to the sensitive plate. The necessary amplification to four or five inches will be far more accurately done when effected in this manner at one operation than when the small negatives are copied afterwards in the enlarging camera, which will magnify all the defects as well as that which is wished to be recorded.

Thirdly, the most experienced photographer who can be obtained should have charge of the photographic operations. It is a mistake to suppose that astronomers, physicists, and photographers can be manufactured for the occasion. To look at the records of the English expeditions, it would appear as if the highest scientific talent possessed by the country were an exclusive attribute of our army and navy. Amongst so many captains and lieutenants it is a relief to find a plain Mr. The French and German expeditions were managed differently—and contrast their results with ours!

VII. THE SCIENTIFIC YEAR.

If we examine with thoughtful attention the progress of human knowledge, as it is preserved to us in the history of civilization, or in the records of the victories achieved by mind over matter, we cannot fail to observe that it has ever been by slow, and often intermittent steps. The energies of the individual mind, even in the most healthful state, cannot be maintained continuously at the same elevation; the powers of thought cannot be kept long at the same state of tension. There must be a lowering down, there must be a relaxation. As it is with the powers of the individual, so is it with the aggregated forces of the mind of mankind. The law of undulations, which is so beautifully manifested in all its subtleties of motion, in the phenomena of light, and the other physical powers in motion, is shadowed forth in the movements of intellectual power with so defined an outline, that we cannot but regard it as a truth, obscure at present through the many difficulties by which all psychological phenomena are surrounded, through the imperfections of our senses, and through the almost entire absence amongst men,

of that cultivation which the inquiry demands. If, however, we will be at the trouble of carefully investigating the history of any discovery, it will be found that, from the first thought,—usually as obscure as the remotest gleanings of nebulous matter,—there have been advances, as if by throbs; periods of action, and seasons of repose, something of brightness being gained by each manifestation of power, until, eventually, the cloudy thoughts gather into rings of brightness, and the disconnected members coalesce into a perfect truth, an ever-abiding and a perfect star.

Electricity is an example of this. We have now the most subtile of the physical powers completely under our control, and we compel it to melt and mould our metals, to blast our rocks, and fire our cannon, to illuminate the ocean around our dangerous shores, and to travel earth and ocean as our Mercury—with fleeter wings than he who was the messenger to the gods. Many men, boasting of the march-of-intellect-age,—of the achievements of science,—regard this as the work of to-day—and with much vanity, and but little truth, refer all this to the efforts of the living race—forgetting that three thousand years have been expended in developing the laws of this power, which is now our familiar slave. *Electron* (amber); the powers of attraction and repulsion possessed by it, and also by the Iron-stone of Magnesia, were known to the Greeks; but Electricity and Magnetism were for ages mysteries, unfolding, as it were, by spasms until in the fulness of time the great truth shone forth.

Heat and Light exhibit similar phases, and show like periods of brightness and of eclipse. Through the dream-land of Alchymy, Chemistry slowly struggled into being, and Astrology, after ages of error, which often presented features of an almost sublime grandeur in its robes of superstition, brought forth the most perfect of the sciences—Astronomy. These facts have been referred to only as showing how small must be the record of real advance within any single year, seeing that so large a period of time is necessary for the development of one simple truth.

The year 1868 cannot be regarded, in any way, as an exceptional one. Indeed, it appears upon a careful examination of the "Chronicles" of progress to fall rather below the average of the past twenty years. There has been a considerable display of industry, and the result of that industry is shown by the accumulation of facts. The perceptive powers have been active, and, of material phenomena new to our consciousness, there have certainly been some notable discoveries, but the evidence is wanting which should show that man's reflecting powers have been largely exercised in the philosophic task of generalization. The materials have been gathered together from the right hand and from the left, they have been carefully named, and placed in order for use, but

the master-mind, to whom is reserved the privilege, to whom is given the power, to construct from those fragmentary truths a systematic whole, is still wanting.

The year may be regarded as one peculiarly inductive. There has been great earnestness amongst the disciples who are devoted to the watching of the lamps which burn in the many shrines within the temple of truth, and many varieties of the constituent parts of the fuel, by which the flames are fed, have been collected by them; but the generalizing mind,—the deductive philosopher,—by whom alone those fragmentary facts can be concreted into a complete whole, has not appeared. The evidences, however, of this will be far more satisfactory to the thoughtful reader than any expression of opinion by the writer of this notice. We shall, therefore, endeavour very briefly to sketch out the more striking facts which have been gained during the year, and indicate, where we can, the paths along which advances may be expected to be made.

Nothing within the range of the sciences of observation can be more satisfactory than the records of Astronomy, especially as it respects the extended observations on the flights of meteors, the spectroscopic analysis of the nebulæ and of the stars, and the investigation of the luminous excrescences observed during the period of total obscuration upon the edge of the eclipsed sun. The shooting star, "a moment bright, then gone for ever," has long been regarded as an interesting phenomenon; but who amongst even the wisest, in past years, dreamed of the remarkable truths which are now opening upon us? By the careful record of all the facts which could be gathered together respecting the appearance, and the characters of those meteors, we have advanced our knowledge in a remarkable manner, and there appears to be no reason for doubting the conclusions at which our observers have arrived, that many belts of meteors are moving with planetary regularity within the limits of the solar system. The most remarkable of those belts is made known to us by the "November flight." The beautiful—almost sublime—meteoric showers, which have been seen about the 14th of that month, have a duration of about five hours. The earth traverses the meteor stratum in space at the rate of 18,000 miles an hour; consequently, this gives us an expanse of 90,000 miles, more or less densely filled with those mysterious bodies. The maximum of intensity of the meteoric bursts lasts but about an hour; within that period these "shooting stars" have been counted by hundreds. How thickly, therefore, must that—probably the central line—of the bed be strewn with them. The part traversed by the earth varies by millions of miles from year to year; therefore, as each November brings again a recurrence of the phenomena, we have the proof

that the meteor zone must be continuous, but that it varies in density. The vastness of these accumulations, the clearly proved periodicity of these star showers, leading to the conclusion, that a considerable number of meteor belts are regularly crossed by the earth in her annual rotation, are amongst the most exalting exercises for the human mind to linger on. The meteor zone is now regarded as an enormous oval hoop in space, extending far out beyond the orbit of Uranus, and this zone, like an elastic belt, has been shown to be disturbed by vast vibrations, probably the result of planetary attractions. By one of these great undulations the meteors have been brought unexpectedly into view this year, when their return was not expected. Of the part played by those small masses of matter in the phenomena of the universe, we know nothing; and we can only hope to establish firmly the hypothesis of that seeming stratification, to which reference has been made, by close observations extended over many years. The supposed relation, too, of these meteoric belts to the orbits of certain comets, opens out a vast field for speculation, and demands the most cautious observations. The fine hypothesis, or rather philosophic speculation of Hock, on the phenomena of swarms of meteor corpuscules, crowding from space into the solar system is, only named to show how much we require to be guided by the severest laws of induction in considering this tempting subject.

The delicacy of Spectroscopic analysis can never fail to excite a large share of attention. During the year the examination of the nebulæ with the spectroscope has given strength to the reasons for supposing that the light by which we discover the gaseous nebulæ is emitted from nitrogen and hydrogen. This beautiful instrument has told us other truths. By it we are enabled to measure the rate at which the earth passes through the waves of light reaching it from any source; and we have discovered, with high probability, that the nebulæ are not moving towards or receding from us, but that the bright star Sirius is approaching the solar system at the rate of nearly 29½ miles in every second of time. Of all the discoveries of the year, however, no one is more remarkable than that addition to Solar Science, (which is certainly peculiarly the science of our own age,) so recently made by Mr. Lockyer and M. Janssen, which informs us that the red prominences which have been observed during several total eclipses of the sun are luminous gaseous matter, giving in the spectroscope the lines which belong to burning hydrogen, with an indication of some other substance, probably new to us, although there are suspicions that it may be carbon. It is nearly thirty years since several experimental photographers drew attention to the fact that the solar spectra obtained by them gave evidence of some peculiar protecting influence existing around the edge of the sun—that is, that light of

a different character emanated from the edge of the solar orb, from that which was radiated from the centre of the disc. Beyond the mere fact, nothing could be satisfactorily made out of this; but now we have in all probability a key to the solution of the problem.

Mr. Stone's discussion of the observations made in 1769 on the transit of Venus, leading to a correction of the sun's distance from us, which he determines to be 91,000,000 instead of 95,000,000 miles, shows the degree of exactness which is now attainable in astronomical calculations. The most remarkable feature of the astronomy of the day is the intense desire to test by the utmost severities of analytical science the correctness of observed facts. We have shown how valuable the spectroscope has been to the astronomer. As an instrument of research in the hands of the chemist, it has not of late proved strikingly profitable. There are many observers who, by determining with all possible exactness the character and positions of the dark lines of the solar spectrum, and the bright lines of flame spectra, are doing most valuable work for future use; but, with the few new metals discovered by its aid, there has been a repose which is not easy of explanation. Chemistry has indeed put aside, as it were, for a season its analytical labours, and the science now dwells with delight amidst its synthetical achievements, which, it must be admitted, are beautiful, curious, and seductive. It is to be feared that the beauty of the laws which regulate the composition of compound bodies, and the pleasure of producing either new organic substances or of forming well-known ones by the discovery of novel methods for effecting the intercombination of elements, may lead men away from the more valuable analytical investigation of Nature's own productions. The changes which may be rung upon a peal of bells are absolutely insignificant in comparison to the number of bodies which might be produced by the intercombination of the known elements. An alchymist—one of the last of his race—after contemplating the multitude of created things, and the discoveries of his still imperfect science—said, "I marvel not that God has created so many things, but rather that He did not, from the material at His command, create an infinitely greater number." The present phase of chemical science will no doubt give place eventually to one of more exact investigation than heretofore, and enlarged generalizations. That industry and mental skill which is now given to nomenclature and notation, will be employed in the higher labours of working out those problems upon the solution of which depends our knowledge of natural phenomena, and our power of applying such knowledge to the useful purposes of life. Chemistry is the handmaid to all the natural sciences; hence, as to astronomy, so to geology does she lend her valuable aid.

The discussion "On Chemical Geology," which has excited much attention, and which has been carried on with great skill by

two well-trained experimentalists and philosophers, leaves us at the end exactly where we were at the beginning. "Going back to the earliest forms of created matter" is launching a frail bark at once into all the doubts and difficulties of the nebular hypotheses and cosmical fancies;—it is plunging into a dark dreamland, in which there is ample room and verge enough for the play of the most volant and erratic imagination, but from which we are not likely to gather any guiding truths. As exercises for well-trained minds, who desire something, as the phrase goes, "to break upon," such speculations are all very well. But if the same mental labour—the same chemical skill—had been bestowed on the things of to-day, instead of on the speculative conditions of the beginning, which can never be determined, the world would have reaped an advantage which is now exceedingly problematical. From Chemical Geology it is but a step to Geology itself. The year has not produced any discovery of great novelty, but it has given evidence of the industry of our geologists. The discovery of Eozoon in the Laurentian rocks of Canada was of great interest. One of the most important discoveries recently made in Palæontological Science is analagous with it. It is the detection of what appears to be the remains of a terrestrial flora, in certain Swedish rocks of Lower Cambrian age—the supposed equivalents of our Longmynd rocks. A peculiar interest attaches to this discovery, inasmuch as it carries back the appearance of terrestrial vegetation upon the earth's surface through a vast interval of time, no land plants having previously been known older than the Upper Ludlow beds. The Swedish fossils now discovered appear to be the stems and long parallel-veined leaves of monocotyledonous plants, somewhat allied to the grasses and rushes of the present day. These plants apparently grew on the margin of shallow waters, and were buried in sand and silt. Although it is probable that several species and even genera may occur in the sandstone blocks which have been examined, they are provisionally included in a single species, to which the name of *Eophyton Linnæaum* has been given. Eophyton, therefore, stands by the side of Eozoon—the one being, in the present state of our knowledge, the earliest land plant, as the other is the earliest animal organism. Our Chronicles will give the details of this interesting discovery, which cannot find a place in a sketch of yearly progress. Reference to these important records — notes for the future historian of the progress of scientific knowledge—will show that many questions of considerable importance to the future of geological science are being discussed with much earnestness. In most cases a decision can only be arrived at after the most cautious examination of extensive districts of country. It is to be regretted that in some of the discussions which have during the year excited attention, there has

been more evidence of a desire for victory than for the elimination of truth.

Physical Science has its numerous workers, who, devoting themselves to its various branches, are opening out roads to future discoveries which will possibly be of considerable importance. The examination of the radiant powers is being followed up with much zeal, and many trained minds, peculiarly fitted by nature for the work, are eagerly seeking for the solution of many problems which still remain unsolved in relation to heat and light radiations and electrical manifestations. Without for a moment venturing to question the truth of the undulatory theory (the weight of talent and testimony brought to bear on it is too overpowering to admit of that), we cannot but express a fear that the interpretation of some of the phenomena of solar radiations has been retarded, by refusing to see any explanation save that which belongs to wave-motion. To this circumstance may be referred the almost entire absence of research on the chemical powers of sunshine. Many important facts, as they now stand, do not *appear* to come within the law of undulations (they may possibly be shown to do so), and hence they have been put aside. Thus one of the most fertile fields of inquiry —the chemical activity of the solar radiations (ACTINISM)—rich with the promise of discoveries of high value, is entirely neglected by the experimentalists of the present day. This is, it must be admitted, partly due to another circumstance. As soon as the chemical action of the sun's rays had been rendered so familiar to the most untrained operator that he could, from the sensibility and simplicity of the processes given to him, scarcely fail to produce a photographic picture of much excellence, and the science became an art, the scientific investigator drew aside, as though he disliked to admit that he was seeking after truth for its money value. Here is, however, a vast inquiry bearing in a direct and remarkable manner on organic growth and on inorganic combination, which lies fallow.

The investigations on the Osmose forces advance certainly towards a solution of the mysteries of molecular attraction, and particularly of the phenomena of the action of surfaces. The indications of an uncontrollable power, dissimilar to any of the physical forces already named, are unmistakable. A power—a force—which can overcome the gigantic attraction of the earth's gravitation, and which can break up, by mere mechanical effort, the strongest chemical affinities, must be amongst the most potential of the physical agencies. At present it appears to us that the full value has not been given to the discoveries made by Graham, Deville, and others in this direction. A remarkable series of facts has been accumulated; they have been investigated with the most perfect appliances of induction; and the results

cannot be gainsayed. Many years cannot roll away before the power of deduction must be brought to bear in all its strength upon this gathering; and the generalization of the true philosopher must evoke a new and mighty spirit from the charmed circle, and bind it to do man's bidding

The physical sciences have been sought to aid the investigations of the physiological student, and some striking facts have been recorded, showing how necessary it is to examine the phenomena of organization in relation with the operation of the physical agencies, Light, Heat, and Electricity, and the laws which regulate chemical affinity.

Zoology and Botany, Mineralogy and Crystallography, have, during the year, been worked, as it were, in obedience to the same law which has regulated the progress of the other branches of science Inductive inquiry has been the rule, deductive generalization the exception. Archæology, Ethnology, and Philology have been progressing—we hope with a greatly improved system of inquiry. The poetry of the past is gradually disappearing before a rigid spirit of inquiry, and the history of man, as preserved to us in his works and in his words, is being won from the grave, from mounds, from the caverns, and the lake-dwellings of buried ages.

In this brief sketch it has been our object to show that valuable facts have been gathered during the past year, and that much intelligence and industry has been expended in carefully labelling those treasures and arranging them for future use. The study of names has been cultivated, to the injury, we believe, of the more enlarged culture of ideas. Still, arguing from the past, through the present, to the future, we are convinced that the time is not far distant when the accumulated materials will be, by the efforts of some philosophic mind, converted—probably by one gigantic effort—into a structure beautiful in its truth and holiness.

We are advancing steadily towards a realization of the fact that mind, and mind only, is the ultimate source of power. No mechanical, no physical energy can be available for good to man without the concurrence of mind. Every practical application of science is a sermon on this text—Mind is the master of Matter. We live under the "Reign of Law;" but every fact discovered, every speculation of any value uttered, carries forward the never-to-be-controverted truth that Law cannot be without a Law-Giver—consequently, that all the laws which the mind of man is steadily evoking from the arcana of space and time, are the material manifestations of the energies of one Almighty mind.

R. H.

CHRONICLES OF SCIENCE,

Including the Proceedings of Learned Societies at Home and Abroad; and Notices of Recent Scientific Literature.

1. AGRICULTURE,

And Recent Agricultural Literature.

A good example of the serviceableness of the chemist, rather as the critic and commentator than as the guide of the agriculturist, occurs in the recently published volume of the 'English Agricultural Society's Journal.' The clover plant removes from the soil large quantities of those substances on which its fertility is generally supposed to depend. It takes, indeed, according to Dr. Voelcker, in the paper to which we refer, more potash, phosphoric acid, lime, and other mineral matters which enter into the composition of our cultivated plants, than any other crop usually grown in this country. How obviously, then, must it be for the interest of the wheat crop, that the clover which precedes it on the land should be consumed where it grows, grazed and depastured by sheep or other animals, so that the substance of the crop may be returned to the soil from which it came, instead of being cut for forage and taken green to the feeding-house or stable, or mown for hay, or harvested when its seed has ripened—being in all these cases altogether taken from the land. The ash constituents of the plant would thus be ready for the crop succeeding it, instead of merely enriching the general dung-heap of the farm, to be applied elsewhere. It is, however, the fact, not only that the clover plant, which takes so much nutriment from the land, is the best possible preparation for wheat, but that the wheat crop is better after a clover crop cut and carried off the land than after clover fed upon the field where it has grown. This, of course, was not at all to have been expected, but Dr. Voelcker, modestly taking his facts from the actual experience of the farmer, instead of enforcing a necessarily imperfect theory as the corrective of mistaken practice, finds on investigation a sufficient explanation of them in the following circumstances, by which, of course, the theory of the subject must for the future be limited and modified. During the growth of clover a large amount of nitrogenous matter accumulates in the soil. This is due partly to the decaying

leaves, dropped during the growth of the crop, and partly to an abundance of roots, which are stronger and more numerous when clover is grown for seed than when it is mown for hay, and also when it is mown for hay than when it is fed off by sheep. The nitrogenous matters in the clover-remains are, on their gradual decay, finally transformed into nitrates, thus affording a continuous source of food on which cereal crops especially delight to grow. That the clover plant which robs the soil is, nevertheless, a fertilizer of it, is illustrated in every example of a failing clover crop. We remember seeing on the wheat field of a farm near Oxford deficient strips stretching parallel across the land, which were explained by the fact that the clover seed-barrow had here and there missed; so that, whereas elsewhere the contents both of subsoil and of atmosphere had, by a vigorous plant of clover, been accumulated within the surface soil for the benefit of next year's wheat crop, here the subsoil and the air, robbed by no clover plant, had contributed nothing of their abundance, and the surface soil was proportionally the worse. The same truth tells to some extent on the comparison of a clover crop fed off with one allowed to ripen; for the development of roots, being checked when the produce in a green state is fed off by sheep, in all probability then leaves less nitrogenous matter in the soil than when clover is allowed to get riper, and is mown for hay. And this, no doubt, accounts for the observation made by practical men that, notwithstanding the return of the produce in the sheep excrements, when the clover is fed off green by sheep, wheat is generally stronger, and yields better after clover mown for hay. We are quoting Dr. Voelcker's words as well as his conclusions; and the whole research appears to us a notable example of the way in which the scientific man can most serviceably discuss farm practice for the benefit of the farmer.

Among the other papers in the current number of the 'English Agricultural Society's Journal' is one by Messrs. Lawes and Gilbert, on the "Home Produce, Imports, and Consumption of Wheat," to which attention should be directed. It shows that the average produce of small experimental plots of wheat upon the Rothamsted Farm, under the three several circumstances of "no manure," "continuous dressings of farmyard dung," and "continued dressings of various artificial manures," is a perfectly trustworthy guide to the character of the crops generally throughout the kingdom. It illustrates the fact that the growth of wheat has of late years gradually diminished in this country, having fallen in England from 3,400,000 acres in 1850 to 3,140,000 acres in 1867, and in Scotland from 210,000 acres in 1854–57 to 110,000 in 1866–67. The average produce of this crop per acre is the

subject of detailed discussion, and the following are the figures arrived at as true of the last sixteen years:—

AVERAGE ACREABLE PRODUCE OF WHEAT.

England and Wales	$28\frac{3}{4}$	bushels per acre.
Scotland	$27\frac{3}{4}$	" "
Great Britain	$28\frac{5}{8}$	" "
Ireland	$23\frac{7}{8}$	" "
United Kingdom	$28\frac{1}{4}$	" "

Among the other facts to which this elaborate paper leads we may quote the following:—That the average annual consumption of wheat per head of the population is about $6\frac{1}{3}$ bushels in England and Wales, scarcely $4\frac{1}{4}$ bushels in Scotland, and only about $3\frac{1}{3}$ bushels in Ireland; or for the whole of Great Britain about 6 bushels, and for the whole of the United Kingdom about $5\frac{1}{2}$ bushels per head. Taking the population of the United Kingdom to be about 30.800.000, and the average consumption of wheat to be $5\frac{1}{2}$ bushels per head, this gives a present requirement of rather more than 21,000,000 quarters annually. And with a reasonable theory both of the increase in population and of the gradual increase of consumption per head, the requirements of the country may be no less than 23,000,000 quarters annually five years hence. Unless, then, the home produce of the country shall largely increase, there will be required over the next five years an average importation of between nine and ten million quarters of wheat per annum.

We may mention as illustrative of that change of cropping to which Mr. Lawes in his discussion of this subject had adverted, that the practice of taking barley in immediate succession to wheat upon the land is gradually increasing; being justified, first, of course, by the fact that good crops are thus obtainable, but also, as compared with what was thought good practice years ago, by the increased facilities both of efficient tillage and liberal manuring which English farmers now possess. By the aid of steam cultivation, thorough autumn tillage is now of easy accomplishment; whilst, though the wheat crop taken after beans, and still more after clover, which itself succeeds a grain crop, very often leaves a stubble foul and needing fallowing, yet in ordinary seasons there is ample opportunity for a thorough cleansing of the land before the winter; and as regards manuring, our guanos and superphosphates enable the farmer to keep the land stocked with fertilizing substances, however it be cropped. Thus Mr. C. S. Read, M.P., at the Norwich Meeting of the British Association for the Advancement of Science, declared:—"I have this year, with a dressing of 1 cwt. of guano and 2 cwt. of superphosphate per acre, grown on a wheat stubble that had been dug 12 inches deep with the steam-cul-

tivator in the autumn the best crop of barley I ever produced, the land being now perfectly clean, and in the best possible condition for next year's root crop. And I see no reason why this extra white straw crop need frighten any land agent, provided always the farm be in a high state of cultivation." During the coming year there will, no doubt, be a good deal of what is thus called cross-cropping; owing to the need of keeping clovers for another year, for the young clovers have very generally failed, owing to the drought of 1868. But we may say with Mr. Read that there is no need of any fear that the fertility of the land must suffer on their account. In fact, it is now well understood that a farmer may crop the land very nearly as he pleases without injuring the owner of it, provided he uses the means of tillage and manuring which he now possesses, and which his own best interests would lead him to employ.

The cheapening of the superphosphate manufacture, owing to the abundance of mineral phosphate in England, Spain, and Germany, and other countries, is one of the most important facts in the recent history of English agriculture. That which a few years ago cost 6*l.* or 7*l.* a ton, containing only 15 to 18 per cent. of soluble phosphate of lime, is now sold at a price which is virtually one-half less. And it quite deserves a record in an Agricultural Chronicle that the chairman of the South Lincolnshire Tillage Association was able the other day to inform the members that he had completed a contract for the delivery of 1000 tons, containing 26 per cent. of soluble phosphate, at 4*l.* 2*s.* 6*d.* per ton, to be delivered free in bags at any of the Great Northern Railway stations within 80 miles of Lincoln. It must, however, be added on the other side, that in consequence of the large exports of sulphate of ammonia to the sugar-growing districts of Germany and the colonies, all ammoniacal manures are rising in price, guano is commanding its full market value, and sulphate of ammonia in particular has advanced from 12*l.* to 17*l.* 10*s.* per ton.

To turn now to another subject:—The condition of the labourer —a question which we have several times had to name during the past year, as having been urgently pressed upon the public attention by the labours of the Rev. Canon Girdlestone, Mr. Baily Denton, and others, is again brought vividly before the public mind by the recent report of Her Majesty's Commissioners appointed to inquire into the employment of women and children in agriculture. The points in which it seems from their report that the Commissioners expect the best result to follow any active interference on behalf of agricultural labourers, are the provision at a fair rent of allotments of land for cultivation by cottagers, and the cheapening and improvement of the cottages. To the subject of benefit societies, savings banks, &c., they propose referring in a further publication.

It is, of course, impossible to state in a single page the substance of so full a description of the condition of the English agricultural labourer as is given in this blue book, and we must be satisfied therefore with commending it to the careful study of our readers, who will find on its perusal not only how much need there is in the facts of the case for earnest effort everywhere on the part of benevolent men, but also how many benevolent men in all classes of society are earnestly desirous and laborious in the effort that is already everywhere being made.

No account of the agricultural proceedings of the past quarter is at all complete which omits to mention the efforts of local agricultural societies, and the many instructive lectures, papers, and discussions which are thus published, first locally, and then through the agricultural papers generally. Among those of the past few months, we may specify a capital account by Mr. Scott Skirving, before the East Lothian Agricultural Society, of the natural history of the farm, so far as the birds, which are at once the friends and enemies of the farmer, are concerned; also a good report, by Mr. Henderson, of Stirling, before a farmers' club in that neighbourhood, of the relations of the sciences of Geology, Botany, and Chemistry to the practice of the farm. To Mr. C. S. Read, M.P., we owe an excellent report on the improvements of late years in the agriculture of Norfolk, read before the British Association at their last meeting; to Mr. Harding, of Somersetshire, a useful lecture before a Cheshire farmers' club on the cheese manufacture; to Mr. Everett, of Newbury, a paper on the social as well as the directly practical results of small farms and long leases; to Mr. Saunders, of Watercombe, in Dorsetshire, a good paper on roots as food for stock; to Professor Coleman, before the Chamber of Agriculture for the North Riding of Yorkshire, a lecture on artificial manures; to Mr. E. Scrutton, of Borobridge, a report on the implements of the farm; to Mr. Hallett, of Brighton, a history of his own experiments in maintaining the pedigree of cultivated wheat and barley; to Mr. Startin, before the Midland Counties Farmers' Club, a discussion of the incidence of the poor's rate as affecting the character of cottage property; to Mr. Mechi, a discursive and suggestive lecture on the undeveloped character of British agriculture; and to Mr. J. K. Fowler, of Aylesbury, a very excellent history of the influences which railways have exerted in the promotion of agricultural improvement. The two last-named lectures were given before the London Farmers' Club. We have not enumerated a quarter of the subjects which have thus all over the country been made the occasion of vigorous discussion at farmers' meetings, and which agricultural readers find reported at more or less length in the agricultural weekly papers. Certainly, however, the Agricultural Chronicle of the quarter would be altogether imper-

fect if it had not thus referred to that constant and formal discussion before local societies in every county, of points in the theory and practice of the profession which is almost a distinctive feature of English agriculture, as compared with the other occupations in which Englishmen engage.

A last word may be given to one among the wilder theories which have thus engaged attention, as it has only recently once more presented itself to readers—the so-called "transmutation of grain." Every now and then a farmer relates in perfect good faith that he has sown oats and cut them down repeatedly until, a year, or perhaps a second year thereafter, on permitting them to grow and seed, they have turned out wheat. The recent occurrence of disqualifications at Birmingham and Islington of pigs which had been entered for exhibition—on the ground that an inspection of their teeth showed that they were not all of one family, as the condition of the competition required them to be—enabled the 'Agricultural Gazette' the other day thus to expose the folly of this "transmutation" theory: "Here, in the animal world, where the womb carries but one family at a time, where the birth is notorious, and everything in the whole history of the produce is a matter capable of record and claiming observation, no certainty seems possible; for the young are taken for exhibition, and it is protested by experts that they are of different origin. But the impossibility of any confidence about parentage, which even in our shows of live-stock occasionally occurs, is necessarily multiplied a thousandfold where the mother is the soil, carrying in her fertile womb at once the germs of myriads of families, where the period of gestation is indefinite, and where the facility of new seeds, new germs, being accidentally deposited, is excessive. In the face of risks like these, the occasional stories of Oats being sown, and Wheat being ultimately reaped, go for absolutely nothing. The antecedent improbability of there being any real connection in such a case between the sowing and the reaping is so enormous, that no scientific man would think it worth his while to make an experiment to test it. And certainly the risks of the experiment are so great, that no other than a scientific man is competent to conduct it."

2. ARCHÆOLOGY (Pre-Historic),

And Notices of Recent Archæological Works.

Pre-historic Archæology received a new impetus when Dr. Hooker, in August last, recalled attention to the semi-savage populations of India which are still erecting megalithic monuments. The importance of the investigations of these cromlechs and dolmens

seems, however, to have already aroused attention in India; and in the April number of the 'Proceedings of the Asiatic Society of Bengal' is an interesting paper by Mr. Mulheran, "On the Crosses and Cromlechs which are found in great abundance on both banks of the Godavery, at Katapur, and elsewhere." The cromlechs, in which the remains of either one or two bodies appear to have been interred, usually consist of a number of upright stones sunk in the ground in the form of a square, covered by one or two large slabs of sandstone. They are considered by the author to be of Buddhist origin.

The crosses are of the Latin form, and are made of one piece of stone 10 or 11 feet high, of which about 7 feet are exposed above the ground. They do not appear to have had any connection with the cromlechs, and were probably erected as memorials of the faith of Christians buried in their vicinity.

In a subsequent number of the Proceedings of the same Society, Lieut. J. S. F. Mackenzie reports the discovery of a great number of cromlechs in the vicinity of the town of Veerajpett, in South Coorg. The cromlechs were found covered by large mounds of earth, evidently artificial. One of them consisted of six large stones, surmounted by a huge flat slab, the whole being divided into two compartments by a large centre-stone. The two front slabs had each, at the top and immediately below the superincumbent stone, peculiar apertures of a segmental form, about 2 feet by 1 foot 8 inches. Many other cromlechs were discovered, possessing similar openings, which the natives consider proof of these structures having been the abodes of the pigmy race described in their legends, the apertures having supplied them with the means of ingress and egress. Lieut. Mackenzie, however, considers that these openings were simply used for the purpose of introducing cinerary urns and the bones of the members of the family, as they died one after the other. In these sepultures several antique-shaped urns and pots were discovered, composed of thick red and black highly glazed pottery. Some of the vessels were tripods, while others were supported on four feet. No bones were found in them, either calcined or in their natural condition; but iron weapons were tolerably abundant, and included a spear, some large javelins and arrows, and the hilts of daggers. It is satisfactory to find that upon the discoveries of these remains being made known to the Indian Government, sums of money were granted to carry on the investigations.

During Dr. Erdmann's survey of the Quaternary formations of Sweden,* he has been able to throw considerable light upon the nature and position of the most ancient monuments of that

* 'Exposé des formations Quaternaires de la Suède,' par A. Erdmann.

kingdom, which are described as tumuli, runic stones, circles, fortified enclosures, inscriptions traced upon the rocks, dolmens, and sepulchral chambers. The ancient fortified enclosures (borglemningar), ordinarily situated on the summit of an eminence, are often several miles inland, and are composed of one or more concentric walls, constructed of great blocks of stone, some of which are 10 cubic feet in dimension. Within the walls of the enclosure are found traces of habitation; and from time to time, deeply sunk in the mud, at the base of the eminence upon which these hill-forts are situated, the remains of ancient boats have been discovered. Iron rings are also reported to have been found at the bottom of the rock, to which they may have served to moor the boats There can be little doubt that we have here evidence of the gradual recession of the sea, and that these ancient enclosures, now high and dry, were constructed upon points more or less surrounded by water.

Two more instalments of the 'Reliquiæ Aquitanicæ' have been issued during the quarter. They are almost entirely occupied by a description of the celebrated cave of Cro-Magnon, situated in the valley of the Vezère, between the village of Les Eyzies and the railway station of that place. The cave, which is 15 mètres above the river, and 73·25 mètres above the sea-level, is formed by a projecting bed of Cretaceous limestone, the *débris* of which forms the lowest bed of the floor. This bed is succeeded by three layers of ashes, separated from one another by thin beds of calcareous *débris*. The uppermost of these is overlain by red earth with bones, which underlies the thickest layer of ashes, bones, &c. The ash-bed is surmounted by a yellowish earth with bones and flints, and that by another bed of hearth-stuff, the rest of the cave being filled up by calcareous *débris* and the rubbish of the talus. From the yellowish earth at the back of the cave the remains of five human skeletons were obtained, of which four have been recognized as belonging to adults (three male and one female), and the other to an immature infant. Associated with these remains were multitudes of perforated marine shells, principally belonging to the common Atlantic species *Littorina littorea*, a worked amulet of ivory pierced with two holes, carved antlers of reindeer, chipped flints, &c. The fauna found associated with the sepulture in this case, and in the layers of hearth-stuff, comprised fourteen or fifteen species of mammals and one bird, and consisted of the remains of an enormous bear, the mammoth, the great cave-lion, the reindeer, the spermophile, &c.,—the bird being possibly referable to the Crane genus. The cave itself, as proved by the occurrence at all levels of flint scrapers, seems to have served at different times as the habitation of the same race of nomadic hunters, who, when the accumulated refuse and *débris* had raised the floor of the cave to an inconvenient

height, returned to it only as a place wherein to bury their dead. The skeletons undoubtedly belong to people of the age of the reindeer, and M. Pruner-Bey refers them to his Mongoloid group, and to the Esthonian type. The human remains, both with regard to their condition and to their proportions, exhibit several peculiarities, which space will not permit us to notice.

In the 'Anthropological Review' for October is an article by Professor P. Broca, "On the Ancient Cave-Men of Périgord;" but as the article is only an abridgment of a memoir, which will appear in the 'Reliquiæ Aquitanicæ,' we defer our notice of it until it shall appear in its proper place, stating here, however, that the author considers that we have in the Les Eyzies' skeletons evidence of a tribe, "entirely different from any other race, ancient or modern, that we have ever seen, or heard of."

In the annual report of the Smithsonian Institution for the year 1866 is a paper, by Dr. D. G. Brinton, "On the Artificial Shell-Mounds and Deposits," which occur in great numbers along the south coast of the United States, especially in Georgia and Florida. These mounds consist of the detached valves of *Ostrea Virginica*, *Venus mercenaria*, and *Unio Virginiana*, and contain flint arrow-heads, fragments of pottery, and charcoal. Some of them attain enormous dimensions—one at the mouth of the Altamaha river, covering ten acres of ground, and containing about 80,000 cubic yards. Another, about four miles from the mouth of Crystal river, in the form of a truncated cone, 30 feet in diameter and 40 feet in height, is exclusively composed of oyster-shells and vegetable mould; with forest trees, some of them 4 feet in diameter, growing upon its surface.

The gigantic scale of the mounds serves easily to distinguish them from the Kjökkenmöddings of Denmark, which seldom attain to a height of more than 10 feet. Dr. Brinton considers them to be the work of known tribes of Indians; but, even if it be so, what length of time is required for the gradual accretion of such immense accumulations, and to what purposes were they applied?

In the same report, Mr. C. Ray describes the discovery, on the left bank of the Cahokia creek, at the northern extremity of Illinois town, opposite St. Louis, of a place where the manufacture of earthenware had been carried on by Indians. The pieces of pottery were discovered near an old fosse, and varied from $\frac{1}{8}$th to $\frac{5}{8}$ths of an inch in thickness, according to the size of the vessels. They were made of clay, mixed either with coarsely pulverized Unio shells or siliceous sand, and were coated generally on the exterior, but sometimes on both sides, with a thick layer of paint. The aboriginal potters usually formed their vessels by hand, but in some instances appear to have modelled them in baskets woven of rushes and willows, so as to produce a rough ornamentation. The fragments

are decorated with lines, or combinations of lines and dots, and in the majority of cases the edge of the vessel is turned over so as to form a rim, the bottom being rounded or convex. Of the antiquity of this pottery the author is not prepared to give an estimate, although there is little doubt that the manufacturers of it were the Cahokia Indians, who were dwellers on the creek until a comparatively recent period.

The discovery of two "crannoges" in the lake of Ballyhoe, Co. Monaghan, is described by Mr. G. Morant in the 'Proceedings of the Kilkenny Archæological Society' for January, 1867. The drainage of the Glyde river, which runs through the lake, has permanently reduced the level of the water by several feet, leaving exposed upon the shore flint-flakes, knives, scrapers, celts, and arrow and spear heads. Ashes were generally found near the flint implements; and, in one instance, a dark-coloured glass bead, and in another, a *leaden bullet* were discovered associated with flint-flakes. The greater part of the implements were included in the peat, but some were found lying on its surface, and others on its rocky subsoil. On the great "crannoge" was a mound principally composed of ashes, containing sharpening stones, implements of iron, and leaden bullets; on its shore, a bronze pin, and a flint spear-head were found, and from the edge of the lake, close by, were obtained flint arrow-heads, hatchets, &c. Some of the flint implements were highly finished, but others were as rude as those of the Amiens pattern; and Mr. Morant argues from the intermixture of these two types with instruments of bronze and iron, that most of them were used at one and the same time by the same race of men,—the ruder weapons being the implements of the common people, while the more highly-finished arrow-heads and bronze pins were the weapons and ornaments which adorned the persons of the chiefs. The occurrence of leaden bullets certainly points to the comparatively recent occupation of the "crannoge," but archæologists will require a much more careful examination of this lake-island before they will feel convinced that the generally accepted and well-defined ages of stone, bronze, and iron, are confusedly mixed together in the manner described by the author.

Colonel A. Lane Fox has published a very interesting description of "Roovesmore Fort, and Stones inscribed with Oghams, in the parish of Aglish, County Cork." This fort, or "Rath," is in the form of an irregular circle, about 130 feet in diameter, measured from the crest of the innermost parapet; beyond this is a ditch about 17 feet in breadth, and beyond the ditch another parapet of 10 feet base and 3 feet high, the ditch being between the two parapets. This structure was probably a fort, as it is well situated for defence, on the top of a gentle rise, and is nowhere commanded from the outside.

Nearly in the centre of the interior space is the entrance (though probably not the original one) to the crypt, of which every Rath possesses one or more. This crypt appears to have been originally of a quadrangular form. Six upright slabs had been placed as jambs, longitudinally, in two lines, at about two feet from the sides of the chamber. Upon the tops of these, heavy slabs of unhewn stone were laid transversely, as lintels, and upon these again rested other longitudinal slabs of the same kind, placed side by side, the edges nearly touching, so as to form the roof.

The chief interest of Colonel Lane Fox's paper is centred in these last-mentioned slabs, for on examining them from beneath by the light of a candle, he found that two of them which lay contiguous to one another had their edges scored with Oghams. Our space will not allow us to follow the author's interesting description of these marks, nor his arguments in support of the conclusion that they are of *greater antiquity than the building of which they formed part*. We shall have performed our duty as chroniclers by directing attention to the pamphlet, and to the fact that the slabs themselves may now be examined in the British Museum.

Before concluding our Chronicle, we should notice the publication of a second edition of M. le Hon's popular work* on Fossil Man. Besides the addition of the new facts which have been brought to light since the first appearance of the book, considerable space is devoted in this edition to the investigation of the cosmical laws which have brought about the Quaternary and Glacial periods; and to a *résumé*, by Professor G. Omboni, of Darwin's theory, of which he is a warm supporter.

3. ASTRONOMY.

(Including Proceedings of the Astronomical Society.)

Since our last Chronicle appeared further intelligence has been received respecting the operations of those who went or were sent to view the great eclipse of August 18; but we have little to add to what we then wrote. We now know that the photographic operations of Major Tennant's party were not so successful as the telegram first received had led us to hope. The negatives arranged for were duly exposed, notwithstanding the unfavourable condition of the sky, light cirrus clouds interfering seriously with the photographic energy of the sun. As might be anticipated, the negatives were under-exposed. Owing also to concentration of the nitrate-of-silver solution, resulting from the heat of the climate, the negatives,

* 'L'Homme Fossile en Europe.'

besides showing but faint traces of the corona, were all covered with spots.

The chief fruit of the expeditions has been the discovery that the rose-coloured prominences are gaseous. This discovery has already led to one of the most interesting applications of spectroscopic analysis ever yet made by astronomers.

We must premise that two years ago, in a paper addressed to the Royal Society, Mr. J. Norman Lockyer called attention to the possibility that spectroscopic analysis might avail to exhibit indications of the existence of the coloured prominences. He said, "May not the spectroscope afford an evidence of the existence of the red flames which total eclipses have revealed to us in the sun's atmosphere, although they escape all other methods of observation at other times?" Not content with pointing out this method, Mr. Lockyer applied it to the search for prominences, making use of a spectroscope with which he had already been able to analyze the light of the solar spots. He failed, however, in detecting any traces of the prominences with this instrument; and, indeed, he was led to the conclusion that the prominences are not gaseous. "A diligent spectroscopic analysis," he wrote last July, "has not revealed any bright lines. This is strong negative evidence that they are not masses of incandescent vapour or gas."

So soon, however, as the news from the eclipse expeditions showed that he had come to this conclusion too hastily, he prepared to renew the search with an instrument which was (at the time) being constructed for him by Mr. Browning, the optician; and on the 20th of October he succeeded in detecting the bright line spectrum of a prominence.

But in the meantime, unfortunately for Mr. Lockyer's claim to priority, M. Janssen, who had been one of the first to detect the true nature of the prominences, was led to conceive the notion that their spectra may possibly become visible when the sun is shining with full splendour. He did not lose any time in putting his ideas into practice; for the day after the occurrence of the eclipse he succeeded in observing the spectrum of a prominence. Thus, two months before Mr. Lockyer, he had solved the important problem of "grasping and measuring by spectral analysis phenomena before invisible."

Had M. Janssen sent home intelligence of his success by the same means as he had employed in the matter of his eclipse observations, his claim to the merit of the discovery would have been indisputable. This, however, he did not do. He sent a letter containing an account of his researches, and it happened, singularly enough, that this letter reached the President of the French Academy of Sciences a few minutes after Mr. De la Rue had read before the Academy a detailed account of Mr. Lockyer's researches.

Who is to have the merit of the discovery? As M. Faye remarks, "the priority of the idea belongs to Mr. Lockyer, but that of its fruitful application rests with M. Janssen." He suggests that the honour of the discovery should be accorded equally to both observers.

By means of the new method it will be possible to chart the prominences from day to day and from hour to hour. Already we have learned two important facts respecting them. In the first place, we now know that they are continually changing in figure and arrangement, as was indeed to be expected from their flame-like character. Secondly, we now know that sodium is not an element in the structure of the protuberances. The spectrum of the sun being brought into direct contact with that of a prominence by the new method of observation, no measure is required for the determination of the position of the bright lines forming the prominence spectrum. The orange line which had been supposed by Lieut. Herschel and others to be the double line of the metal sodium, is now found not to agree in position with the dark line D of the solar spectrum, which is known to be due to absorption by sodium-vapour in the sun's atmosphere. Thus the vapour to which the bright orange line in the prominence spectrum is due cannot possibly be that of sodium. It seems clear, however, that the red and green lines are due to burning hydrogen.

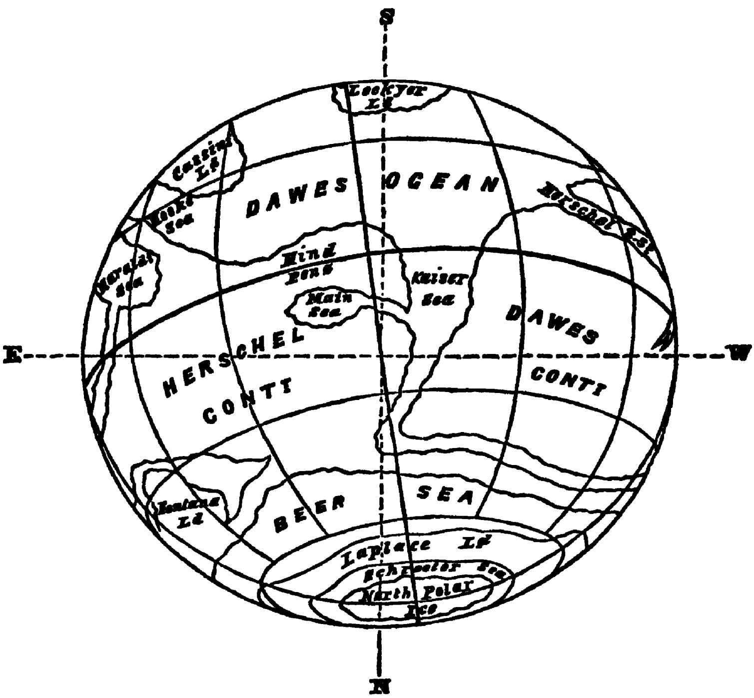
We mentioned that, according to received views respecting the meteoric zone to which the November shooting-stars are due, there was but little prospect of the display being seen in England this year. Our views were subsequently confirmed by a letter addressed to 'The Times' by Mr. Hind, the superintendent of the 'Nautical Almanac,' in which he stated that the probable hour of the earth's passage through the zone would be six o'clock in the afternoon of November 13th, at which hour England would be on the sheltered side of the earth. However, the anticipations of astronomers were not fulfilled by the result. The display was well seen in several parts of England and Europe on the morning of the 14th of November. The only explanation of this peculiarity which seems at first sight available is that the meteoric zone had been swayed from its mean position (as respects this part of its length) by the attractions of the planets, and that thus the earth passed through it several hours later than had been expected. The news that the display has been seen well in America points also to the widening out of the zone.

The planet Mars will be in opposition on February 13th next, and for several weeks before and after that date he will be very favourably situated for observation. He will not, indeed, be so near to the earth as at many oppositions; in fact, he will be so close to his aphelion that he will be almost as unfavourably situated, as

respects distance, as he possibly can be when in opposition. But on this very account he should be studied all the more carefully, as the portion of his globe which will be turned towards the earth is that which has been least studied, owing to the fact that it is never presented towards us except when Mars is in or near aphelion.

In Figs. 1 and 2 the presentation of Mars at the approaching opposition is exhibited. The features are those presented in Proctor's

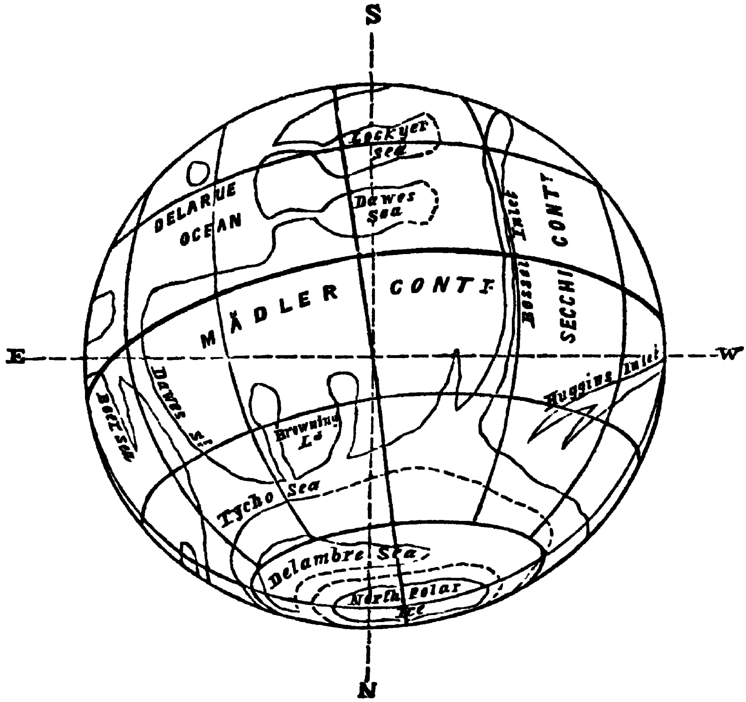
FIG. 1.



charts, which are derived from a series of drawings by the late Mr. Dawes. Many of the features of the northern hemisphere require, however, to be carefully re-observed, since Mr. Dawes made his observations on this hemisphere with an instrument considerably inferior in power to that which he made use of in observing the southern hemisphere; and (as we have noticed) the northern hemisphere is only turned towards us when Mars is in aphelion. We must also remark that it is not merely the question of presentation which has to be considered. When Mars is presented towards us as shown in Figs. 1 and 2, he is also presented in almost exactly the same way towards the sun. Hence it follows that the northern hemisphere is enjoying the martial summer; and accordingly the martial skies are clearer over that hemisphere, and its features are proportionately more distinct. This is no mere speculation respecting the condition of the martial globe, but corresponds exactly with the

peculiarities which have been observed by all our leading telescopists.

FIG. 2.



Mars will have a high northern declination during the next four months, and therefore his definition will be good, in ordinary observing weather, when he is on or near the meridian.

Many observers have been successful in obtaining good views of the recent transit of Mercury. Amongst the observations, the most important are those which were made at Greenwich under the superintendence of the Astronomer Royal. He was enabled to employ no less than six telescopes, including the great equatorial, in observing the transit. In every instance the planet was observed either to assume a balloon shape, or to throw out a ligament, as it approached the edge of the sun's disc. Mr. Airy remarks that he had always been disposed to refer the peculiarities seen during the transits of Venus in 1761 and 1769 to the imperfections of the telescopes employed, but having now seen what has happened with telescopes unimpeachable in character, he thinks differently. He ascribes the peculiarities to the effects of irradiation. With the great equatorial, Mr. Stone could see no trace of any spot upon the disc of Mercury. He could see a ring of light round the planet.

Mr. Huggins observed the transit with his 8-inch equatorial, using the full aperture. The weather was on the whole favourable,

as the bright granules over the sun's surface could be well seen. The planet appeared as a round, evenly-defined spot, with an annulus of light one-third of its apparent diameter, having a well-defined boundary, and appearing rather brighter than the sun's disc. Nearly in the centre of the planet's disc there was a spot of light. As the ring was seen when the darkest part of the neutral tint sliding wedge was made use of, and in fact rather better then than when the shade employed was lighter, Mr. Huggins considers that the ring cannot be looked upon as a mere optical effect of contrast. An atmosphere round Mercury hardly seems to be a sufficient explanation of the ring of light. As for the point of light on the disc, that is an old difficulty. Probably the fact that Stone could see no such point with the great Greenwich equatorial, will lead to the opinion that the appearance is connected in some way with the quality of the telescope employed.

At a recent meeting of the Royal Astronomical Society, the Astronomer Royal stated that he had obtained from Dr. Miller, of Cambridge, evidence confirmatory of the connection which has been supposed to exist between comets and meteors. It will be remembered that Mr. Huggins's analysis of Comet II., 1868, showed that that object consisted of carbon in the state of incandescent gas. It appears that there are four meteoric stones, at least, which contain carbon. Of these, one fell in the south of France, one at the Cape of Good Hope, one at Debreczin, in Hungary, and the fourth at Orgeuil, in France.

The number of discovered asteroids has now reached 106.

There will be an eclipse of the moon, visible in England, on the morning of January 28th. First contact with the penumbra will take place (at Greenwich) at 11 h. 18·2 m. P.M., January 27; first contact with the shadow at 0 h. 29·2 m. A.M., January 28; the middle of the eclipse at 1 h. 38·2 m.; and last contact with the penumbra at 15 h. 58·2 m. Somewhat less than one half (more exactly 0·450) of the moon's diameter will be eclipsed. The first contact with the shadow will occur at 50° from the northernmost point of the moon's limb towards the east; last contact at 31° towards the west.

Proceedings of the Royal Astronomical Society.

Dr. O. Pihl has laid before the Astronomical Society the results of a micrometric examination of the stellar cluster in Perseus. He has been prosecuting this examination since the year 1860, with a view to obtain, within comparatively small probable errors, a mensuration of all the more conspicuous stars, sufficiently exact to serve as a basis for investigating at some remote date the mechanism of the system. The instrument which he has made use of in these re-

searches is a refractor, $3\frac{1}{4}$ inches in aperture, equatorially mounted, by Lohmeyer, of Hamburg. We have not space to describe in full the various arrangements adopted by Dr. Pihl to secure accuracy. Our readers will probably be more interested in learning that, as far as the researches have yet gone, there would seem to be indications of movements having taken place since the epoch of Bessel's measurements. The mean declination of seven stars examined by Bessel is 4″ 27 south of the mean declination as now observed. "Is it probable," says Dr. Pihl, "that this difference is owing to errors in observation or reduction, and to no physical change?" This is a question which cannot be answered until the course of time enables astronomers to obtain some satisfactory evidence respecting any process of change which may be going on.

A remarkably interesting paper is supplied by Mr. Stone, on the subject of the observations made upon the transit of Venus which took place in 1769. Our readers are doubtless aware that the estimate of the sun's distance, which has so long found a place in our treatises of astronomy, was founded upon those observations. When other methods of determining the sun's distance had led to results differing by three or four millions of miles from the value hitherto received, astronomers were somewhat at a loss to understand how it was that so faulty a value should have resulted from a series of observations so elaborate, and apparently so successful, as those which were made upon the transit of 1769. It will be remembered, that the calculation of the sun's distance had been managed by Encke, and there seemed every reason for supposing that he had spared no pains to treat the observations which came under his hands in the most careful and satisfactory manner. An attempt was made by Powalky to show that the observations of the transit could be made to agree with modern determinations of the sun's distance. But, according to the opinion of the best mathematicians, Powalky allowed himself far too great freedom in selecting the materials he made use of. Professor Newcombe, of America, had been more successful in representing the observations of 1769. Still, however, there was considerable discordance.

It appeared to Mr. Stone that a new discussion of the observations of 1769, if made with due care, would necessarily lead to a clearer view of the sources of systematic error, or wrong interpretation which might be feared and ought to be guarded against, in the observations proposed to be made of the transits of 1874 and 1882. In the course of his investigations he was led to the detection of several grave and fundamental errors, which had previously been made in the discussion of the observations of 1769, and to a value of the solar parallax, entitled to be received with confidence.

The great difficulty lies in the fact that at the moment of true internal contact Venus does not present the appearance of a circular

disc, but is apparently pear-shaped. This phenomenon is due to the effects of irradiation, by which the sun's apparent diameter is increased, while that of the planet is diminished. But the great difficulty in judging of the observations made in 1769 has lain in the necessity of following some law or other as to the choice of what shall be held to be the true moment of internal contact. The error which Stone has discovered in Professor Encke's mode of treatment consists in the fact that the latter did not apply a uniform law to the observations which came under his notice; that, in fact, in one or two instances, he misinterpreted the words of the observers. "I consider," says Mr. Stone, "that by simply interpreting strictly the language employed by the observers, I have been led to a solution which satisfies the whole of the ten observations, and gives, at the same time, from the equations of condition, a satisfactory result for the difference between the time of internal contact and the breaking of the black drop." The value of the solar parallax deduced from the new treatment of the observations is 8″ 91, a value which agrees in the most satisfactory manner with that which had been obtained as the mean of other methods of estimating the parallax.

We must remark, however, that Professor Newcombe considers Mr. Stone's interpretation of the observations made in 1769 as untenable.

Mr. J. Tebbutt, jun., supplies a series of observations made by him upon the star η Argûs. He compared this singular variable with neighbouring stars. It appears from these observations, that η Argûs has not exceeded the sixth magnitude during the past two years. Thus we are compelled to reject the theory of Professor Wolf, who assigned a law of variation according to which the epoch of minimum brilliancy should have occurred in 1861, and the magnitude of the star should have been 3·6. Certainly η Argus is the most remarkable star in the whole heavens. A quarter of a century ago, it outshone the brilliant Canopus, and rivalled Sirius itself in splendour; now it can only just be detected with the naked eye on a very clear night.

Two biennial meetings have been held of the Astronomische Gesellschaft, under the presidency of Professor Argelander, and the heads of the subjects discussed appear among the notices of the Astronomical Society. Amongst these, we may notice the following:—It has been suggested that the older observations of the Periodic Comets should be re-examined. Four points have been specified—the new determination of the places of the stars of comparison, the calculation of the auxiliary quantities with the now-received values of the constants for the times of the appearance of the comets, the calculation of solar ephemerides for these times, and lastly, the publication of the originals of the older comet observations. It appears that the calculations for the comets of

Encke, Faye, Brorsen, D'Arrest, and Tuttle, are being proceeded with; but a list of thirty-one comets, from 1830 to 1867, remains for further discussion. A wish was expressed that astronomers who are occuping themselves with any particular comets, would put themselves in communication with the Society. A programme was received for the observation of all stars, down to the ninth magnitude, between circles of declination 2° S. and 80° N. The observatories which had offered to take part in the work were Berlin, Bonn, Helsingfors, Leipzig, Mannheim, and Leyden.

4. BOTANY, VEGETABLE MORPHOLOGY, AND PHYSIOLOGY.

The Fertilization of the Scarlet-runner and Blue Lobelia.—Mr. T. H. Farrer, a gentleman previously unknown to fame, but evidently a careful observer of nature, set himself to work upon the question as to whether other plants besides those described by Mr. Darwin (Orchids, Primula, Linum, and Lythrum), might not have a structure which provided for the fertilization of one's ovary by the pollen of another flower. As Mr. Farrer observes:—"To an amateur, dismayed by the difficulties of botanical classification, perplexed by his own incapacity for microscopical dissection, and disgusted by the mere cataloguing of species, Mr. Darwin's suggestion that the true account of the structure and functions of flowers is frequently to be found in their capacity for cross-fertilization with the pollen of other flowers, is a ray of light which opens out an endless field of interesting observation." We wish there were more such amateurs. We cannot give Mr. Farrer's observations, which are very detailed, and published in the 'Annals of Natural History' for October. He shows that there is such an arrangement of the parts of the flower of the Scarlet-runner, that a bee, alighting and searching for honey, necessarily shakes any pollen off his proboscis on to the stigma, whilst, by another device, his proboscis gets covered with the pollen of this flower as he withdraws it, and is ready to fertilize another. In Lobelia, Mr. Farrer describes a very remarkable disposition of parts, which act so that when a bee visits a Lobelia flower, pollen is ejected, in small quantities at a time, on the exact spot on his back on which it should be placed in order that it may be carried to the stigma of another flower, the stigma in these flowers also being so arranged that, at the very next flower visited by the bee, the stigma sweeps off the previously acquired pollen.

The Double Cocoa-nut.—Dr. E. Perceval Wright, Professor of Zoology in Trinity College, Dublin, visited, in 1867, the Seychelles

Islands: he stayed there some time, making valuable observations on botanical and zoological subjects. One matter which very greatly occupied his attention was the condition and growth of the forests of *Lodoicea*—the celebrated Double Cocoa-nut of these islands. Before the Seychelles were discovered, the nuts used to be picked up floating on the seas, and were considered rarities of extraordinary value: at length their home was discovered, and now their whole history is known, excepting how or whence they came to the Seychelles. There is no palm like them, that can be possibly pointed to as an ally, or as a possible descendant from a common ancestor, unless we pitch the date of that ancestor far back in time. And this is what we must do; we must suppose that for ages the Lodoicea has grown on the Seychelles, and has become so modified in that great space of time, that it is now quite unlike any other palms in many important particulars. It was feared, some time since, that the Double Cocoa-nut was about to become extinct, like most other living things formed in the microcosm of an ocean-island, when exposed suddenly, through man's agency, to the influence, more or less, of the macrocosm; but this fear was set at rest, and Dr. Wright tells of several large forests containing thousands of these trees, many from 100 to 150 feet in height. Dr. Wright finds that the growth of the stem depends very much on the soil in which it grows. Of a number planted in 1812 on Silhouette, some flowered and bore fruit in 1851, being then 26 feet high and 4 feet in diameter at the base; whilst others which, though close by, were in very poor soil indeed, had no stems at all, and have borne neither fruit nor flowers to this day. It is unsafe, Dr. Wright thinks, to judge of the rate of growth of trees by *planted* specimens.

The "Haofash" of Cochin China.—The 'Moniteur' gives an interesting account of a tree called Haofash, which grows on the mountains of Baria, in French Cochin China. It grows wild in the forests, hidden among Lianas and other creepers, which render the wooded mountains of that country almost impervious to the traveller. Nor do the inhabitants, generally speaking, know the botanical or medicinal properties of this plant, so that it remains a secret in the hands of the bonzes and physicians. MM. Condamine and Blanchard, two French travellers, have at length succeeded, after much fruitless search, in finding this tree—having bribed a bonze to disclose it to them. The bark is stripped from the tree in its third year, when it is about 24 feet in height. The operation is performed in June, when the tree has neither blossoms nor fruit; it is hewn down, and then denuded of its bark methodically in slices about 2 feet long and 3 or 4 inches broad. The bark of the Haofash is outwardly of an ash-gray colour, and inwardly brown; it has a strong aromatic smell and a slightly bitter taste. When chewed it reddens the saliva; it is a powerful styptic; it is ad-

ministered by the physicians of the country in cases of colic, diarrhœa, and dysentery.

The Ordeal Poison-nut of Madagascar.—Dr. Bennett, of Sydney, writes an account of this tree in the 'Journal of Botany.' Specimens of it have been naturalized in New South Wales, and in the Botanical Gardens at Sydney there is a very fine tree of it, which somehow or other obtains a mysterious sort of respect from the visitors to the gardens, who, although they do not hesitate to gather from other flowers and shrubs, stand in awe of the Ordeal-tree. The flowers are very fragrant, of a crimson colour, and appear in November and December. The plant belongs to the natural order *Apocynaceæ* and its native name is *Tanghin*—whence *Tanghinia.* The fruit is of the size of a hen's egg, containing a hard stone or nut, the kernel of which is white, of a bitter taste, and has remarkable poisonous properties. The poison of the ordeal-nut acts *directly* upon the heart and muscles. When used by the natives as a detector of crime, the kernel is pounded and administered to the supposed criminal. Frequently sickness is caused, and the accused then escapes. If not, the poison is rapidly absorbed, and death ensues. A difference of colour is said to exist between those kernels which produce only vomiting and those which produce death; and the friends of an accused person will stand by and object to certain nuts being used, The officers are said to administer these two varieties in a partial way, but it is not very certain that they can really discriminate between the virulent and less active kernels. Dr. Bennett suggests that there may be two species of *Tanghinia* existing in Madagascar, differing in the intensity of their poisonous power. The milky juice of the *T. Manghas* is said to be used as a purgative, and according to Rumphius the natives boil and eat the leaves mixed with other pot-herbs, which thus act as a gentle laxative. The bark is also used in Java and Amboyna as a familiar cathartic, the action of which is said to be very similar to that of senna. Manghas is the name given to the tree in its native country.

New British Plant.—*Potentilla Norvegica* has been discovered by Mr. G. S. Gibson, in Wicken Fen, near Upware, in Cambridgeshire. It was found growing on the side of one of the marsh ditches, and was carefully identified by comparison with the specimens in the herbarium of Linné and in that at Kew. The plant is inconspicuous, and likely to be passed over, except when in flower. Its geographical distribution renders it unlikely to be found native in the southern parts of England, and Mr. Gibson cannot account for its introduction in so rough a spot, and it is not a plant that he has ever seen in cultivation. We would suggest the possibility of the barges passing on the Cam, which is little better than a canal, as the means of introducing the plant. There are superphosphate

works at Cambridge, and possibly certain boat-loads of foreign phosphate may have been brought by Upware thither.

New British Seaweed.—Mrs. Alfred Gatty has found in Cardigan Bay, and Dr. J. E. Gray has described in the Ann. and Mag. Nat. Hist. *Elachista stellaris.*—There are eight other British species of *Elachista,* which Dr. Gray arranges in three groups. Mrs. Gatty also found *Gigartina pistillata* in fruit in Blackpool Bay. The late Dr. Harvey saw the specimen, and recorded it in the herbarium of Trinity College, Dublin.

Palu.—Some time ago a very small quantity of a fine silky substance was brought to England from California under the above name, and it was used as an object for the microscope, on account of its beautiful structure. Mr. Bingham, in his very interesting paper "On the Volcanic Phenomena of the Hawaiian Islands," says,—"*Palu* is the silky covering of the opening fronds of several species of tree-ferns, and is exported in large quantities to California, for beds,* &c." The trade is so extensive that "corduroy roads" are made to the station where it is collected, and whole districts are leased for the "Palu business," and there is a large number of "Palu pickers." The *Palu* is collected at Kelanéa, which is the most tropical region in Hawaii. The tree-ferns have stems 15 feet high to the base of the frond, and 8 or 12 inches in diameter.

Plants without Roots.—The French Academy has received a paper from M. Duchartre on certain plants which vegetate without roots. In South America people will suspend such plants from a balcony by a thread, without their being in contact with anything else, and yet they will grow and blossom in this strange position. In our hothouses we see them, simply stuck upon a piece of wood or cork, thrive beautifully without any roots. The question therefore is, How do they live? M. Duchartre, to discover the secret, has instituted a series of experiments on a plant of this family—the *Tillandsia dianthoidea.* Two tolerably equal sprigs of it, without a vestige of roots, were tied separately to two slices of dry cork from the same piece. They were then freely suspended in the air, and weighed from time to time. One of these plants, A, never got any water at all; the cork of the other, B, on the contrary, was moistened every second or third day. After the experiment had been continued 103 days, A had lost one-third of its weight, but had nevertheless produced blossoms and a small root; B, on the other hand, was extremely vigorous, and had increased one-eighth in weight. M. Duchartre thence concludes that these plants require water, but do not absorb the moisture of the atmosphere.

Reproduction of the Diatomaceæ.—In the last number of the 'Quarterly Journal of Microscopical Science' Count Castracane

* P. 426.

describes some important observations, which lead him to believe that Diatomaceæ reproduce by means of germs. He describes what he considers as zoospores having cilia and containing diatoms. The young germs do not present the brown endo-chrome, but are of a bluish-green colour. Count Castracane's observations are given in detail and are of great importance, since we may hope that they will lead to further observations in this country and elsewhere. It is strange that whilst there are hundreds of Diatomaniacs, the questions of the physiology and anatomy of these organisms remain so long doubtful. Max Schultze has settled the locomotive question, but there remain others unanswered. We believe that most Diatom-men would scorn to look at a frustule that had not been boiled in nitric acid, and hence the incompatibility between the number of students (*sic!*) and the great ignorance prevailing as to Diatomaceæ.

Fungological Gastronomy.—The Woolhope Naturalists' Field Club recently devoted a day to investigating the Fungi of their district. The party met at Hereford, and under the direction of Mr. Edwin Lees, F.L.S., and of Mr. W. G. Smith, they proceeded to collect a vast variety of both poisonous and edible mushrooms, from Holme Lacy Park and the neighbouring hills. It was to the edible forms, however, that the members turned their attention principally, as they were to be cooked and eaten at dinner after the excursion. With the fish and the soup came the first novelty in the form of "Oreades ketchup." It was good with either, and was pronounced by all present a brilliant success. A dish of beefsteak, animal and vegetable, was served, deliciously mingled to the advantage of both, and at the same time a dish of the *Fistulina hepatica*, the "Liver fungus," or "vegetable beefsteak," by itself was handed round. The slices were cut from a large specimen, gathered in the morning. The next Agaric to appear was *Hydnum repandum*, the "spiked mushroom," from Haywood forest. It was stewed and broiled, and those members of the Club who had resolved themselves into a committee of critical taste, and to whom therefore all dishes were immediately brought fresh and hot, quickly separated the Agarics from their gravy, and found them excellent, and particularly the broiled ones, not at all unlike *oysters*, to which they have been compared. Then followed the Parasol Agaric (*Agaricus procerus*), and after this, the Fairy-ring Champignon (*Marasmius oreades*), broiled on toast, after the admirable receipt of Soyer. A dish of *Agaricus prunulus*, or *Orcella*, was also served, simply stewed, and was declared to be "delicious." After dinner our convivial fungologists listened to four instructive communications on various matters relating to Fungi: their spores—those that are British, why they ought not to be eaten, and those belonging to Fairy-rings.

Flora of Middlesex.—The work having this title, by Dr. Henry

Trimen, of St. Mary's Hospital, London, and by Professor Thiselton Dyer, of Cirencester College, will be speedily sent to press, and may be expected to be published by Mr. Hardwicke early this year. The work will not be a mere record of the occurrence of species, but much pains has been given to tracing out the origin of the Flora as far as possible and (what is interesting from an antiquarian point of view) the former extension of species over parts of Middlesex now become London. This sort of observation has, too, a great value in connection with the causes of the extinction of species.

Flora of Bucks.—A second 'List of Buckinghamshire Plants,' including the additions which have been made to the known Flora of the county during the past year, will shortly be published. It is requested that anyone possessing information on the subject in his possession will forward the same to James Britten, High Wycombe.

Chair of Botany at Dublin.—Professor Dickson having accepted the Chair of Botany at Glasgow University, the lectureship in the College of Science and the professorship in Trinity College, Dublin, became vacant. Dr. Perceval Wright, Professor of Zoology in Trinity College, was the natural successor of his late colleague to the more valuable post. Dr. Wright is well known as a teacher of botany, and an original explorer in botanical science as in zoology. For some reason, however, Dr. Wyville Thompson, of the Queen's College, Belfast, is selected for the Government appointment, and therefore for the University chair also.

University of Vienna.—The celebrated botanist, Dr. Karsten, of Berlin, has been elected to the Chair of Vegetable Physiology at Vienna, vacated by the retirement from office of Dr. F. Unger.

5. CHEMISTRY.

(Including the Proceedings of the Chemical Society.)

The preparation of oxygen has already been alluded to in these Chronicles on more than one occasion, and several processes have been described by which this gas may be obtained indirectly from the atmosphere. Closely allied to the preparation of oxygen on a large scale is that of chlorine, and it has recently been announced that a Belgian chemist has devised a new process for generating this gas. He first forms sulphate of sesquioxide of iron, by the direct combination of this oxide with sulphuric acid, and then mixes the sulphate obtained with three equivalents of chloride of sodium or other convenient chloride. Upon heating the mixture in dry air, the chloride of sodium is said to yield all its chlorine.

Mr. Mallet has continued his experiments on the production of oxygen, and has now modified his process in such a manner that he can also obtain chlorine on a large scale. As certain novel or but slightly known reactions have brought this process into some note, a few explanations are necessary. The fixation of atmospheric oxygen upon protochloride of copper allows two results to ensue; either the disengagement of oxygen, supposing the desired end be to collect that gas, or the decomposition of chlorhydric acid and liberation of chlorine, should the production of that body be desired. The absorption of oxygen by protochloride of copper is spontaneous, and takes place at the ordinary temperature in a few hours, provided the air be sufficiently moist, and especially if the surfaces be renewed. If the temperature be raised the absorption is more rapid, and this is the most important part of the question, for by raising the temperature to between 100° and 200° C., or even higher, in the presence of steam, absorption may be regarded as almost instantaneous.

If upon protochloride of copper, heated to 100° or 200°, commercial chlorhydric acid be slowly dropped, steam alone will be disengaged, and supposing the addition of acid to be slow enough, and the access of air and renewal of surface sufficient, the odour of chlorhydric acid will be scarcely perceptible, and the whole protochloride will transform into anhydrous bichloride, which, when heated in a close vessel, instantly disengages chlorine. The simultaneous absorption of oxygen and chlorhydric acid is an important and interesting fact, because the extraction of the chlorine from the acid takes place in this case by means of the atmospheric air, and in an absolutely direct manner. With gaseous chlorhydric acid the action is the same, in fact better, provided the acid gas contain, as is always the case, a certain quantity of steam, and that the accession of air be sufficient. The presence of water is necessary to the absorption of oxygen by protochloride of copper. Oxidation and chlorination take place very quickly at high temperatures, but the great advantage is that they yield dry products, which is very convenient, inasmuch as steam is frequently a source of inconvenience and alteration of apparatus. From a manufacturing point of view, it may be considered that 100 kilogrammes of protochloride of copper, mingled with sufficient inert matter to facilitate manipulation, will produce practically from three to three-and-a-half cubic metres of oxygen, or from six to seven cubic metres of chlorine. As four or five operations at least may be performed in twenty-four hours, it is plain that 100 kilogrammes of substance will produce from fifteen to eighteen cubic metres of oxygen, or from 200 to 300 kilogrammes of chloride of lime, in twenty-four hours.

The price of the raw material does not exceed one franc the kilogramme, and the loss is ascertained by experience to be always

very small; this is easily understood, as the substance does not leave the retort, but undergoes all the processes within it.

Professor Stas gives the following as the best method of preparing sulphurous acid, a gas which is largely used as a reducing agent and disinfectant. A current of sulphurous acid is obtained by attacking, by means of copper, pure sulphuric acid, diluted with from one-half to two-fifths its volume of water. To make sure of the purity of the sulphurous acid, pass the current, at first through water contained in a large washing flask, then through two Woulfe's bottles completely filled with pumice-stone broken into small fragments and moistened. The moistened pumice-stone, previous to its introduction into the bottles, is twice calcined with sulphuric acid, so as to free it from the chlorides and fluorides which it often contains.

Professor Wöhler, to whom we owe the first published account of aluminium and magnesium, has lately published the following facts concerning the metal cerium. The colour of the metal is intermediate between the colour of iron and that of lead. The metal is lustrous when polished; it is malleable. Its density is about 5·5 at 12°. Exposed to the air it loses its lustre, and becomes slightly blue. It feebly decomposes water at 100°. Hydrochloric acid dissolves it with energy; concentrated nitric acid converts it into clear brown oxide; the dilute acid dissolves it. By evaporation, a white salt is obtained, which leaves, after calcination, a brown oxide, insoluble in nitric acid and in dilute sulphuric acid. Concentrated sulphuric acid slowly dissolves this oxide, forming a yellow solution which shows the reactions of ceric salts. Hydrochloric acid dissolves this oxide with disengagement of chlorine, forming a colourless solution. When a globule of cerium is heated by the blow-pipe to dull redness, the metal inflames and burns vividly, forming brown oxide; but upon submitting a globule suddenly to a very high temperature, it burns with explosion, sending out bluish sparks. Cerium powder can inflame below 100°.

The rapid and accurate estimation of the amount of sulphur contained in pyrites is a matter of importance to that very large section of industrial chemists who are interested in the manufacture of vitriol. Professor Wöhler has discovered that hypochlorous acid may be used to transform the sulphur of pyrites into sulphuric acid, which is then estimated by baryta. He directs to finely pulverize the mineral and suspend it in water, through which a current of gaseous hypochlorous acid, or better still hypochloric acid, is passed; this entirely dissolves the pyrites. Hypochlorous acid is prepared by heating a milk of carbonate of lime, through which a current of chlorine is passed to saturation. Hypochloric

acid is obtained by heating in a water-bath a tube supplied with a cork and delivery tube, and containing a mixture of 9 eqs. of oxalic acid and 1 eq. of chlorate of potash.

Professor Wöhler has also published a good method of separating phosphoric acid from bases. It consists in dissolving the substance to be analyzed in a small quantity of nitric acid, and adding to the solution, first nitrate of silver, then carbonate of silver, and well shaking. All the phosphoric acid then combines with the oxide of silver and is precipitated, whilst the bases remain in solution and may be freed from the excess of silver by means of hydrochloric acid.

The element phosphorus has been applied by W. Schmid as a re-agent for metals. When a solution of crystallized phosphorus in bisulphide of carbon is shaken with water, a perfectly white precipitate is formed. The presence of traces of metals causes the precipitate to assume various colours. Thus solutions of copper are precipitated brown; those of silver, black; of mercury (oxide), yellowish brown; of gold, violet. The filtrates contain generally sub-oxides.

In an examination into the action of iodine on the hydrogen compounds of antimony and arsenic, M. Husson has discovered a reaction which may furnish a useful application in toxicological researches. He finds that antimoniuretted hydrogen and arseniuretted hydrogen form iodide of antimony and iodide of arsenic when the two gases are made to pass over iodine. A tube containing a small piece of iodine being joined to the Marsh's apparatus, gentle heat is applied to volatilize the iodine, which, upon condensation, lines the tube. Then, while the tube is still slightly warm, the gas is allowed to pass. If this contains arseniuretted hydrogen, the iodine will be bordered by a yellow line formed of little straw-like masses, having much analogy with iodoform; the iodine disappears completely. With antimoniuretted hydrogen the reaction is less manifest; all the iodine collects, forming a deep ring, orange-tinted on the one side, and brown on the other. But the action of heat enables these two iodides to be distinguished thus:—The yellow iodide of arsenic is transformed, one part into red iodide with disengagement of iodine, the other volatilizes in the state of yellow vapours, which are received on unsized paper; the same phenomenon is produced under the influence of an excess of arseniuretted hydrogen, whence M. Husson is inclined to conclude that a periodide of arsenic is first produced. Iodide of antimony, on the other hand, evolves red vapours, and leaves a little reduced antimony.

Dr. T. Werner recommends the following process to detect the presence of atmospheric air in coal gas:—Ten parts by weight of

anhydrous sulphate of protoxide of manganese are put into a two-necked bottle, and then dissolved in twenty parts of warm water. To this mixture is immediately added a solution of ten parts by weight of tartrate of potash and soda (Rochelle salt), dissolved in sixty parts of water; the thorough mixing of the fluids is promoted by well shaking the bottle; after this there is added a quantity of a solution of caustic potash sufficient to render the fluid quite clear; immediately after this the corks, perforated and fitted with very tightly fitting glass tubes, are placed in the necks of the bottle, which should be entirely filled with the mixed fluid just alluded to. One of the glass tubes—the inlet tube for the gas to be tested—should just dip a little under the upper level of the fluid; the outlet tube, on the other hand, should only reach halfway through the perforation of the cork. A very slow current of gas is now made to pass through the fluid, and kept going for at least 15 minutes, and at most one full hour. In case the gas is quite free from atmospheric air, the fluid in the bottle will remain quite clear; if even traces of air are present, a faint coloration of the liquid will soon become apparent; with a larger proportion of air present in the gas the fluid will soon be rendered, first light brown coloured, and afterwards intensely black. Since these changes of colour are due to the oxidation of the salt of manganese, it is evident that every care must be taken to avoid the presence or access of accidental air; the fluid in the bottle should reach the cork. It is best to cool the bottle during the experiment with ice, if at hand, otherwise with very cold water; the current of gas must be slow.

M. Monnier has discovered a process for refining sugar, which is likely to prove of considerable commercial value. When a current of anhydrous sulphurous acid is passed into a chamber containing coarse sugar, a bleaching action ensues, and three-fourths of the colouring matter of the sugar is destroyed, while no alteration whatever is suffered by the sugar itself. After this treatment, the sugar is strongly impregnated with sulphurous acid, but the presence of this body does not interfere with subsequent operations. About four parts of sulphur are required for every 1000 of sugar, but when the process is in regular operation, the amount of sulphur can be sensibly diminished. The sulphurous acid gas is obtained by burning sulphur in a small furnace adjoining the chamber. When the operation is terminated, the sugar is dissolved in water, and the sulphurous acid neutralized by lime previously converted into sucrate of lime. M. Monnier feared that, in practice, the anhydrous sulphurous acid might modify the sugar, and convert a portion into grape sugar. He has, however, convinced himself that no action of this kind takes place; the proportion of uncrystallizable sugar, found by analysis, after treatment by the process, being always exactly equal to the original amount. In all the experiments

the sugar remained exposed to the bleaching action for forty-eight hours. This process gives excellent results with the strongly coloured West Indian sugars; with samples less coloured the action is not so marked. In the first case, two-thirds or three-fourths of the colouring matter is completely removed.

M. Dumesnil has devised a new process for preserving wine, which is of considerable interest. The cask of wine, uncorked, is placed under an iron bell and the air exhausted; two hours' work is necessary before the noise occasioned by the exit of the air ceases. A vacuum being created, the gases contained in the wine are released from atmospheric pressure and expand sufficiently to break the cells of vegetable fibrin enclosing them, and escape. The withdrawal of 30 or 40 litres of gas occasions no sensible decrease of liquid. M. Dumesnil gives an example of the practical value of his process. He allowed the wines of 1865 to ferment till March, 1866, so as to allow of the conversion of all the sugar and extractive matter into alcohol. At this period he substituted for the usual operations the treatment by the vacuum; fermentation ceased entirely. The wines thus treated arrived at their destination in good condition; with other samples treated in the usual way the result was very different. Notwithstanding four rackings, and possibly four clarifications, the wines have continued to ferment during the whole of the year 1866 and also the commencement of 1867, and they probably still contain gases which will affect them more slowly. M. Dumesnil mentions that his wines of 1867, treated in last March by the vacuum, yielded twice as much gas as those of 1865.

A memoir presented to the Academy comprises the first portion of the results of M. Kolbe on the bleaching of flax. The research has led to the establishment of the following facts:—The gummy substance which adheres to the fibres of flax is nothing else than pectose. The soaking or steeping of the fibre appears to have for its object the determination of the pectic fermentation, and the pectic acid which results remains fixed on the flax, either mechanically or, in part, in the form of pectate of ammonia. The caustic alkalies in the cold form gelatinous pectates, which preserve the fibre from being completely attacked. Pectic acid being weak, the alkaline carbonates have in the cold only a feeble action upon the fibre. Ebullition, on the contrary, transforms pectic acid into an energetic acid—metapectic acid; the carbonates are then strongly attacked, and their employment becomes as efficacious as that of caustic alkalies. The carbonate of soda, even in large quantity, is not a cause of the weakening of the fibre, which loses more strength from the employment of caustic soda, especially when the lye is concentrated. The employment of lime, even in the cold, weakens the fibre considerably, but the chief cause of the destruction

of the solidity of the fibre is too prolonged digestion, particularly with caustic soda. M. Kolbe says, that after having proved the existence of pectose in the unsteeped flax, and of pectic acid in the same flax after steeping, it is to be hoped that the attention of chemists will be drawn to the pectic fermentation, well known, doubtless, as a scientific fact, but of which no one suspected an industrial application of so high importance.

The value of carbolic acid as a cure for the bites of venomous snakes has been made public by Dr. J. W. Hood, B.Sc., of Melbourne. He writes: "I have long entertained the opinion that carbolic acid, taken internally and used as a caustic to the wound, would be found to be beneficial, and, perhaps, a specific cure. That I am right, to a certain extent, is proved by the fact that a friend of mine, a medical man living at Warrnambool, Dr. Boyd, successfully treated two cases of snake-bite with carbolic acid. I am not aware of more particulars than that the first case was a young lad bitten by a tiger-snake, the most venomous these colonies produce, and Dr. Boyd—six hours after the boy was bitten—administered ten drops of pure acid in brandy and water, every few minutes. The effect was magical—from a pallid countenance, slow pulse, and semi-comatose condition, the patient rallied to a bright expression, ruddy glow, and quick pulse, and the recovery, though slow, was continuous and certain."

In a short communication to the 'Centralblatt,' Drs. Bergmann and Schmiedeberg describe a crystalline substance, to which they have applied the name "sulphate of sepsin," obtained from putrefying materials, and which they believe represents the proper poison of organic substances undergoing this kind of fermentation. It is obtained by diffusion through parchment paper, precipitation with corrosive sublimate from an alkaline solution, removal of the mercury by silver, of silver by sulphuretted hydrogen, evaporation, and purification of the residue. Large, well-defined, acicular needles are thus obtained, which are deliquescent in the air, and when exposed to heat, melt and carbonize. They possess a powerfully poisonous action. A solution containing scarcely more than one-hundredth of a gramme was injected into the veins of two dogs. Vomiting was immediately induced, and after a short time diarrhœa, which in the course of an hour became bloody. After nine hours the animals were killed, and on examination their stomachs and large intestines were found ecchymosed and the small intestine congested. Frogs could be killed in the same manner.

There has been only one meeting of the Chemical Society (Nov. 5, 1868), and the space occupied by other matter compels us to defer an account of the proceedings until our next number.

6. ENGINEERING—CIVIL AND MECHANICAL,

And Notices of Recent Engineering Works.

One test of the vitality of the Engineering profession at the close of any year may be found in the list of plans deposited at the Private Bill Office for the ensuing session of Parliament. This year we are glad to find a marked improvement in this respect upon its predecessor, but still the list is not a very full one, and does not give promise of more than a very partial revival from the recent state of depression. The published list contains altogether one hundred and thirty plans, of which sixty are for railways, six for tramways, twenty-four for waterworks, twelve for gas, and the remainder for miscellaneous works of improvement. Amongst the railway schemes, the principal are proposed extensions of the present Metropolitan lines in and about London; a new line, to be constructed with unusual regard to economy in first outlay and in subsequent cost of working, between Brighton and London; and the constantly recurring proposal for a line under the Mersey, between Birkenhead and Liverpool.

The above are, however, works of the future, and such as may be carried out will receive their notice in these columns in due course. We must now turn our attention to giving a brief account of the principal works which have been completed, or in course of progress during the past quarter.

Docks, Harbours, &c.—The works of the Royal Docks at Cork Harbour are progressing very satisfactorily. It is expected that the foundation stone will be laid early in the spring of 1869. There are upwards of 400 convicts employed in various duties, as stone cutters, carpenters, and labourers; and there are in addition 100 men employed by the contractors.

The new Docks at Leith are fast approaching completion, water having already been admitted into them. The excavation of the outer basin is finished, and the quay walls are completed.

The Clyde trustees have decided on at once proceeding with the new Graving Dock at Salter's Croft, Govan, for which Parliamentary powers were obtained last session; and Messrs. Bell and Miller, C.E., have been instructed to take the necessary steps in preparing contract plans for the undertaking. The new dock will be one of the most extensive in the kingdom, capable of accommodating ironclads of the largest dimensions.

The harbour of Irvine, which has been gradually silting up for years, is now in course of improvement, and very extensive works are under construction for that purpose. Those under the first contract, which, however, comprise only a small section of those con-

templated in the scheme of improvements and extensions, are nearly completed.

Leven harbour has long been acknowledged to be quite unsuited for the amount of shipping frequenting it, and as long as twenty years ago extensive improvements were contemplated. Nothing, however, has been done till quite recently; but workmen have at last commenced driving piles at the east end for the purpose of further extending it, and this will, no doubt, be followed by still greater improvements.

On 3rd September, a large floating-dock for Bermuda was successfully launched from the yard of Messrs. Campbell, Johnstone, and Co., of North Woolwich. It is 381 feet long, 124 feet wide, and 72 feet deep, weighing altogether nearly 9000 tons.

Railways.—The St. Pancras Terminal Station of the Midland Railway in London was opened on 30th September last. A description of this huge edifice was given in the last number of this Journal.

The new Railway between Glasgow and Coatbridge, in connection with the North British system, was commenced on the 28th September last. This line is to run direct west from Coatbridge, through the village of Bailliestown, and will be about eight miles in length. The entire line is to be completed by the year 1870.

The Duke of Sutherland has resolved to extend the Sutherlandshire Railway to Helmsdale. The necessary surveys have already been made, and works will be carried on in anticipation of the passing of an act early in the present session.

One of the contracts for the Greenock and Ayrshire Railway is expected to be completed before the end of the year, and the other early in the spring. The line will probably be ready for regular traffic in March or April next.

The East Kilbride Extension of the Caledonian Railway was formally opened to the public on 1st September last. The total length, from Glasgow to Kilbride, is ten miles.

The extension line of the South Yorkshire Railway, from Tinsley to Rotherham, was opened for traffic on the 1st September.

The New York Elevated Railway is expected to prove a great success. The section already completed was to have been opened on the 1st November; surveys have been completed for the remainder of the line, and the company will now proceed to raise money as fast as possible for its construction.

A railway to the summit of Mount Washington, New Hampshire, is now under construction. The station at the starting-point is 2700 feet above the level of the sea, and the road, when completed, will be 2 miles 260 rods long, rising in that distance 3000 feet to the Tip-top-house, with a gradient in some parts as steep as 1 foot in every 3.

The new line of railway between Suez and Alexandria, *viâ* Azazieh, was opened on 8th September. Passengers by the Indian mail will now proceed by that route, which will occupy only ten hours in transit, including stoppages.

Bridges.—The Quincy Railroad Bridge across the Mississippi, connecting the Chicago, Burlington, Quincy, and the Hannibal and St. Joseph Railroads, was opened for general traffic on the 7th November last. This bridge has been built to supersede the ferry, formerly the means of communication between the two lines which are now joined, and an unbroken route is obtained to the Missouri river, and westward to such lines as are constructed in Nebraska and Kansas.

An iron railway bridge is under construction between Louisville, Kentucky, and Jeffersonville, Indiana, which will be just one mile in length. It will have 24 spans, two of 370 feet, and six of 245·5 feet each. It is expected that this bridge will be completed by September 1st, 1869.

Water-supply, Drainage, &c.—During the last excessively dry summer several towns, including Liverpool, Manchester, and Edinburgh, were at one time apprehensive lest there should be a failure of their water-supplies, and this became more particularly felt in the two latter towns. We shall therefore probably soon hear of works being undertaken with the view of rendering available fresh sources of supply.

The works for giving an additional supply of water to the town of Preston were set in operation during the last week of August. The water is taken from the river Hodder, on the borders of Lancashire and Yorkshire, at a point thirteen miles from Preston. The total additional supply thus obtained amounts to 2,200,000 gallons a day.

The Kirkaldy and Dysart Waterworks are progressing favourably. It was expected that the whole of the works at Ballo would be finished by the 1st January, after which a commencement would be made in laying the pipes for the town.

A company recently formed for the utilization of the sewage of Liverpool has made considerable progress with the necessary works. Pipes have already been laid down to the extent of four miles, and it is expected they will shortly be carried out as far as Nice Blundell, where the distribution of sewage will first commence; the pipes will then be carried on to Southport. The deposit well at Sandhills has been sunk, and the pumping station immediately above it will soon be completed.

Miscellaneous.—Tenders have recently been invited for putting in the foundations of the New Fort to be erected on the middle ground-shoal in the Bombay Harbour. The fort is semicircular in plan, of a radius of 100 feet, the circular face fronting the mouth

of the harbour. This will form part of a system of defensive works for the protection of Bombay Harbour, which was determined on some years back. Several of the minor works, comprehended in the defensive system, have already been completed.

A firm of gas engineers and contractors in New York have recently undertaken the erection of gas works at Canton, in China. The main building for retorts, &c., will be 184 feet long, made of iron, and manufactured after the most approved plans. The works will have a capacity to make 500,000 cubic feet per twenty-four hours. All the materials for the buildings, gasholder, and works will be made, fitted, and shipped complete, ready to be put up immediately on their arrival at their destination.

On 24th November the new Smithfield Meat Market in London was opened to the public with some ceremony, by the Lord Mayor and Civic Corporation. The market is a parallelogram, 631 feet in length by 246 feet in width, and covers 3½ acres. The general height of the external wall is 32 feet. There are 162 shops in the market, each about 36 feet by 15 feet; and behind every shop is an enclosed counting-house, with domestic apartments overhead. The lower part is filled in with broad glass louvres, so placed that while air is admitted freely the direct rays of the sun are kept out.

Mechanical.—Peet's stop-valve, which forms an admirable substitute for all other taps, stop-cocks, or stop-valves, is now being largely manufactured by Messrs. Joseph Whitley and Co., of the Railway Brass Works, Leeds. This valve has the advantage of giving an unobstructed line of communication when open, and when shut it comprises two steam-tight surfaces. The opposite internal sides of the valve are parallel, and instead of a single wedge-block, two separate discs are employed, which go down loosely to their bearing, when they are forced apart and driven close home by a conical end to the spindle. Thus, in the event of any obstruction preventing the proper closing of one of the discs, it in no way interferes with the other disc taking a perfect bearing.

A new method of applying steam to the propulsion of canal boats has been tested on the Erie canal. The driving-wheel is placed in the middle of the boat, and rolls on the bottom of the canal, being so arranged as to rise and fall with the irregularities of the bottom. The speed thus obtained is from two to two-and-a-half miles per hour.

A very useful invention has recently been patented by Mr. Andrew Murray, of H.M.'s Portsmouth Dockyard, designed for the purpose of hauling stranded vessels into deep water, in attempting to do which ordinary steam-tugs generally fail completely. The invention consists in fitting one or more powerful capstans on board a vessel which is to be placed between the stranded ship and one or more heavy anchors, laid out in the direction in which it is desired

to move it. The capstans are fitted on the same bed-plate, and can haul upon both chains at once in opposite directions, thus bringing a very considerable pull upon the stranded ship.

A neat arrangement of cut-off gear, for enabling the degree of expansion in a steam-engine to be regulated by the governor, has recently been introduced by Messrs. Shelmerdine, Walker, and Holt, of the Albion Ironworks, Miles Platting, Manchester. In this arrangement the cut-off valve is placed at the back of the main slide-valve, and is moved by the latter by friction, the stroke of the cut-off valve being limited by a link coming into contact with springs on the stops. When the expansion-valve is stopped in this way the main slide travels on without it, and thus effects the cut-off of the steam; and the point in the stroke at which this stoppage of the cut-off valve takes place is regulated by raising or lowering the point of suspension of the link.

A new arrangement of stop-block for railway sidings, &c., is now being introduced by Messrs. E. S. Yardley and Co., of Manchester. The block, which is of cast iron, has bolted to it a pair of clips, which partially embrace two journals. The upper surface of the rail forms a portion of the bearings when the block is raised, but is left quite clear when the block is down. The block is raised and lowered by means of a sliding handle; this handle, when the block is raised, being locked by merely turning it one-fourth round. When the handle is thus turned a disc is exhibited, which indicates that the block is on the rails.

Mr. V. de Michele has lately introduced the simplest and most practical method of combining a screw motion with the ordinary reversing handle for a steam-engine that has yet been suggested. In this the handle works altogether independently of the screw, using its threads as notches. The screw arrangement is placed close below the frame of the engine on the centre of motion of the lever, leaving the handle as clear for ordinary rapid action as in the case of the simple lever.

Engineering Works.—The Chief Constructor of the Navy, Mr. E. J. Reed, C. B., has recently published a work on the subject of shipbuilding, entitled 'Shipbuilding in Iron and Steel,'* which professes to be "a practical treatise, giving full details of construction, processes of manufacture, and building arrangements; with results of experiments on iron and steel, and on the strength and water-tightness of riveted work." Unlike many previous publications of a kindred nature, this work deals with the question of shipbuilding from a purely practical point of view, and appears fully to carry out the author's intention of furnishing fuller information on the subject than has yet been published. The volume

* London: John Murray, Albemarle Street. 1869.

before us is divided into twenty-one chapters, of which fourteen are devoted to descriptions and illustrations of the details of iron and steel ships. One of the remaining chapters gives a description of the mode of work practised in building at the several private and the royal dockyards, and another relates to operations connected with armour-plating; whilst the remainder are filled up with matter of a purely practical character. It would be vain to attempt a perfect review of such a work as this within the space allotted to us, and we can therefore do little more here than notice its appearance. There are, however, one or two points of interest which should not be omitted. In this book, for the first time, we have a detailed account of the changes made in the construction of ironclads, from the 'Warrior' downwards. The arrangements adopted in most of the principal private establishments with respect to the various parts of iron ships are fully described; and separate accounts are given of the methods of iron shipbuilding adopted at the principal yards on the Mersey, the Thames, the Clyde, and the Tyne, as well as a full account of the system practised in the Royal Dockyards in building ironclads. The style in which this work is compiled seems well calculated to fulfil the author's expressed desire that it should be the means of affording information not only to shipbuilders in general, but more especially to the officers and workmen employed in the Royal Dockyards. By order of the Board of Admiralty it will form the principal text-book for examination in iron shipbuilding of candidates for promotion in the dockyards.

Although not exclusively an Engineering work, it may not be inappropriate to notice here an interesting French work, entitled 'Annales et Archives de l'Industrie au 19me Siècle.'* This work is one of the numerous publications that have arisen out of the Industrial Exhibition in Paris of last year. M. Eugène Lacroix is the well-known publisher of scientific works in Paris, and at the opening of the Exhibition he announced his intention of publishing a report on the Paris Exhibition, independent of all Government or other official authority and interference, much in the same manner as 'Tomlinson's Encyclopædia of Arts and Sciences' arose out of the first London Exhibition of 1851. The work at present under notice consists of a series of volumes, purporting to comprise a technology of arts, manufactures, agriculture, and mining, compiled from essays and reports upon the different classes of the Paris Exhibition of 1867, and forming a review of the present state and development of the various branches of industry and applied sciences and arts. The six volumes of which this publication consists certainly form one of the best records of the late Paris

* Eugène Lacroix, éditeur. Paris: Quai Malaquais. 1868.

Exhibition printed in the French language, and it may very fairly be doubted whether there exists anywhere a more useful compilation of treatises on the present state of various branches of art and industry.

It would be impossible to do justice to M. Eugène Lacroix's 'Annales et Archives de l'Industrie' within the space allotted for the purpose; it may therefore suffice briefly to refer to the several subjects therein treated, which belong more particularly to Engineering Science.

A very interesting essay on the study of the influence which the fine arts exercise upon the progress and development of industries and manufactures should perhaps be noticed here, as it unquestionably bears intimately upon the question raised at the late Exhibition on the subject of technical education, having reference particularly to the comparative positions of different countries represented there. A most important subject treated in the various essays is one on Mining and Iron Smelting, by MM. Joulié and Dufrené. M. Michel Rous, Captain of Artillery, and M. Schwachlé have contributed a series of articles on the construction of firearms' ammunition, heavy ordnance, and other war materials, which are carefully illustrated with the most important designs exhibited at Paris. The articles on wood-working machinery, by MM. Raux and Nigreux, are accompanied by cuts of the most modern types of machines made in England, France, America, and Germany. Sugar manufacture and the different processes of brewing and distilling are treated by M. A. Basset and M. J. Grandvoinnet. The report on locomotives by M. Gaudry is illustrated with a series of drawings, showing the different types of engines exhibited, drawn all to the same scale; and a similar arrangement has been made in the case of portable engines. And finally we may refer to a well-compiled and carefully illustrated article on Naval Architecture, by M. G. de Berthein.

It is most important that foreign scientific publications should be carefully studied in this country as well as those by our own countrymen, and the fact that several of our continental neighbours are running us very close in competition for engineering works —albeit their best designs are but too often copies of English patterns—should make our engineers all the more anxious to borrow whatever of useful novelty may be found in their manufactures; and with this view we are glad to hail any addition to foreign engineering science.

A Practical Treatise on the Manufacture of Portland Cement, by Henry Reid, C.E.; to which is added a translation of M. A. Lipowitz's work, describing a new Method adopted in Germany of Manufacturing that Cement, by W. F. Reid.* The gradual

* E. & F. N. Spon: London, 1868.

increase of confidence in, and appreciation of, Portland cement as a building material, and the consequent additional demand for it, has, it appears, hitherto led to an insufficient care in its preparation, calculated to bring its properties into distrust. The object of the present work is primarily to remedy this evil, by instructing the manufacturers in the best practice of the process in all its details, and introducing into English manufactories the method at present adopted in Germany in that branch of industry. Considering how important a position good cement holds in almost all large Engineering works, any additional information calculated to lead to an improvement in its manufacture cannot but be accepted as a real boon. It will, of course, always be advisable that Engineers should sample, and carefully test, every delivery of cement employed upon their works; and it is only by such means, scrupulously carried out, that its manufacture is likely to be kept up to a desirable state of efficiency. Increased demand for a manufactured article too often leads to carelessness in its manufacture; and, as we have already said, it is only by persistent testings that a high standard is likely to be efficiently maintained. The present work shows how the manufacture of Portland cement may thus be successfully conducted.

7. GEOLOGY AND PALÆONTOLOGY.

(Including the Proceedings of the Geological Society, and Notices of Recent Geological Works.)

In last quarter's Chronicle we briefly noticed the publication in the 'Philosophical Magazine' of two instalments of Mr. J. Croll's paper on Geological Time. Its completion in the November number of that magazine enables us to give a *résumé* of the arguments, and the principal conclusions at which the author has arrived.

The question, How far the variation of the eccentricity of the earth's orbit may have brought about the great changes of climate indicated by geological phenomena, has been often discussed, more especially as regards the cause and date of glacial epochs. During the past three millions of years, there have been three periods when the eccentricity attained a high value. The first of these began about 2,630,000 years ago, and terminated about 2,460,000 years ago. The second began about 980,000 years ago, and terminated about 720,000 years ago. The third began about 240,000 years ago, and terminated about 80,000 years ago. The third period, Mr. Croll considers, was the date of the Glacial epoch; the second was that of the Upper Miocene period; while the third corresponded to the Glacial epoch of the Middle Eocene period. Few geologists

believe that during the two latter periods our country passed through conditions of glaciation as severe as it has done during the Post-Pliocene period. Mr. Croll, however, argues that subaërial denudation, by destroying the whole of the land surfaces, has effectually removed all direct proof, although the indirect evidence is very much in favour of their occurrence. From calculations based upon the amount of sediment brought down by the Ganges, Mississippi, and other rivers, it would follow that from the close of the Miocene and Eocene Glacial periods to the present day, supposing the rate of deposition to be constant, 120 feet and 410 feet respectively have been removed and carried down to the sea in the form of sediment. The cosmical theory of climate also requires that if glacial conditions obtained at these periods, warm and equable climates must have prevailed immediately before or after them, and the author maintains that this is just what has happened. In the Turin Miocene, conglomerates considered glacial by Sir C. Lyell are overlain and underlain conformably by strata indicating a sub-tropical condition of climate. The same phenomena are also observed in Switzerland in rocks of the Middle Eocene period, where we find "flysch" closely associated with nummulitic strata, which contain genera characteristic of a warm climate. The Cretaceous and Permian periods afford similar evidence, and in the Post-Pliocene glacial period we have undoubted proof of a warmer climate during part of its duration, as evidenced by the occurrence of animals and shells existing in latitudes where they could not otherwise have lived in consequence of the cold. Space will not permit us to follow Mr. Croll any farther, but we would refer those of our readers who are interested in the subject to the paper itself, which will well repay a careful perusal.

The Woolhope Naturalists' Field Club is fortunate in having for its head-quarters a typical district in British geology, and it has, so far, taken advantage of its position as to publish in the new volume for the year 1867 two papers by the Rev. R. Dixon,—one on the "Geology of the Woolhope District," and the other on "Upper Silurian Fossils." The Woolhope district presents, according to Murchison, one of the best examples of a valley of elevation in the British Islands, and has even been referred to by Humboldt as an instance of the result of what he calls "Vulcanicity." By a continued volcanic action, the Upper Llandovery Sandstone has been upheaved some 9000 feet from its original position, into a dome-shaped mass, exposing on its flanks the superjacent rocks, which underlie the Old Red Sandstone. Fossils from the various beds are very numerous, and it was from the Woolhope Limestone of this district that the new Orthoceratite (*Actinoceras baccatum*), described by Mr. H. Woodward in a recent number of the 'Geological Magazine,' was obtained. The paper is accompanied by a list of the chief localities where the

rocks are exposed, and by suggestions for routes which cannot fail to be of great service to future explorers of the district.

Vesuvius has acquired another historian, in the person of Mr. J. Logan Lobley, who has published a descriptive and geological account of that volcano. No new facts are adduced with which the previous writings of more eminent geologists have not already made us acquainted, but the appearance of the book is especially opportune, when Vesuvius, by another eruption, is again drawing to itself the attention of scientific men.

Palæontologists will be glad to hear of the appearance of the first part of the 'Ostéographie des Cétacés vivants et fossiles,' by MM. Van Beneden and Paul Gervais. We shall, however, defer our notice of the authors' conclusions until the completion of this, as it promises to be, important monograph.

In accordance with the recommendations of a Royal Commission, the Swedish Diet of 1856–57 voted, for a term of three years, a sum of money for a geological exploration of Sweden, and the publication of maps relative to it. Since 1858, owing to grants by future Diets, the work has gone on uninterruptedly, and during the ten years from 1858 to 1867 about 226 square miles have been explored and mapped. One of the results of this survey has been the publication, by Dr. Erdmann, of his investigation upon the Quaternary Formations of Sweden.* He considers that at the close of the first phase of the Glacial period, when the continental glaciers had attained their maximum development, and extended over the greater part of the country, the level of the sea was much lower than it now is, causing the region occupied by the Baltic and the Gulf of Bothnia to be part of the dry land. This was succeeded by an inverse movement,—the sea commenced to rise, and continued to encroach upon the land, until it reached, at the epoch of the transition between the Glacial and Post-Glacial period, a much higher level in some regions than its present limits. The waters then once again commenced to recede, and continued this movement until they had reached, little by little, their present level.

The Scientific Society to which Dr. Reynès intended to communicate the results of his investigations upon the geology and palæontology of the Department of Aveyron having been dissolved, he has published them at his own expense, and we now have before us his exhaustive treatise. Two-thirds of the department are occupied by igneous rocks, but in the arrondissements of St. Affrique and Milhau, the sedimentary rocks are represented by Upper Silurian, the Coal Measures, Permian, Trias (Bunter, Muschelkalk, and Keuper), Infralias, Lower Lias (Middle and

* 'Exposé des formations Quaternaires de la Suède,' par A. Erdmann.

Upper), and Lower Oolite. Coal is found in the west of the department, immediately underlying the Permian rocks, and the thickness of the deposits makes the supply practically inexhaustible. Dr. Reynès believes that other localities only want working to yield coal, and that in St. Affrique especially the sandstone is so easy to mine that there would be great probability of remunerative success. Under the name of Lias, the author comprises the whole of the series of marls and limestones which extend from the top of the Trias to the Oolitic limestone. The Lower Lias (White and Blue Lias) is subdivided into six fossiliferous zones—(1) *Avicula contorta* zone (bone bed), (2) Zone of *Ammonites planorbis*, (3) Zone of *A. angulatus*, (4) Zone of *A. Bucklandi* (Arieten Kalk), (5) Zone of *A. obtusus*, (6) Zone of *A. oxynotus and raricostatus*, and *A. armatus*; the Middle Lias (Marlstone) comprises—(7) Zone of *A. fimbriatus*, and (8) Zone of *A. margaritatus*; and the Upper Lias (Upper Marls, Alum Shales, Possidonia Schists) consists of (9) Zone of *A. Serpentinus* (Possidonien Schiefer), (10) Zone of *A. bifrons*, (11) Zone of *A. jurensis*, and (12) Zone of *A. opalinus*. Several new species are described from these zones, principally from the zones of *A. margaritatus* and *A. bifrons*.

The attention of our palæontological readers is called to the publication of a work by Dr. Gustav L. Mayr, on 'Flies in Baltic Amber.'* We do not give a *résumé* of its contents, as the subject has only recently† been treated at some length in this Journal, in Dr. G. Zaddach's paper "On the Origin and History of Amber."

In the 'Annals and Magazine of Natural History' for November is a paper by Dr. H. A. Nicholson, "On the Distribution in Time of the Graptolitidæ." A careful examination shows that this order may still be considered characteristic of and confined to the Silurian period, notwithstanding the discoveries of the aberrant genus *Dictyonema* in the Middle Old Red of America, and in the Tremadoc slates of this country. The genera, and often the species of this order, are so constant in range and distribution, that they afford reliable data by which to correlate deposits in different parts of the world.

Another large group—the Brachiopods—has been treated in a similar manner by Mr. J. L. Lobley, in the 'Geological Magazine' for November. The vast range in time of this class, its persistence through varied conditions, and its apparent extinction during whole formations, such as the Trias, only to reappear when more favourable conditions obtained, would point to its study as being especially valuable in determining the truth and correctness of any development theory.

* 'Die Ameisen des baltischen Bernsteins.'

† 'Quart. Journ. Science,' vol. v., p. 167.

In the same number is an article by Mr. H. Woodward, "On a newly discovered Long-eyed Calymene, from the Wenlock Limestone, at Dudley." The eye-stalks of the new Trilobite are of remarkable length, and Mr. Woodward has given it the name of *Calymene ceratophthalma.*

Those who are specially interested in the subject, will find in the October number of the same magazine, a reprint of Mr. J. Evans's paper "On the Cavities in the Gravel of the Valley of the Little Ouse, in Norfolk," read before the British Association at Norwich, in which the supposed artificial cavities in or near which flint implements were found are referred to sand pipes.

The concluding portion of Mr. J. A. Phillips's "Notes on the Chemical Geology of the Gold-fields of California" is published in the December number of the 'Philosophical Magazine.' A careful examination of these gold regions has led him to arrive at the following principal conclusions. Quartz veins have been produced by slow deposition from aqueous solutions of silica on the walls of the enclosing fissures. The formation of these veins is often due to hydrothermal agencies, and it may be inferred that they are the result of an intermittent action, the fissures having been sometimes traversed by currents of hot water, and at other times having given off aqueous or gaseous exhalations. It would appear that gold may be deposited from the same solution which gave rise to the formation of the enclosing quartz, and the constant presence in auriferous veins of iron pyrites, which always contain a certain amount of gold, suggests the close connection of this sulphide with the solvent which holds the gold in solution.

In conclusion, we would call attention to the appearance of Dr. J. J. Bigsby's 'Thesaurus Siluricus—the Fauna and Flora of the Silurian Period,' a notice of which, in greater detail, will be found in another part of this Journal.

Proceedings of the Geological Society.

The memoirs published in the last number of the Society's Journal are unusually numerous and interesting.

In the secondary changes which have modified the chemical constitution of stratified rocks subsequent to their deposition, and produced the various forms of mottling and variegation, perhaps no agent has played so conspicuous a part as Iron. Mr. Maw, in an elaborately illustrated paper "On the Disposition of Iron in variegated Strata," has by a series of careful analyses determined many of the appearances connected with ferruginous rocks.

The state of combination in which iron is usually disseminated is the anhydrous sesquioxide, but it also occurs in small amounts

as hydrous sesquioxide, carbonate of protoxide, and as silicates. Mr. Maw inclines to the opinion that the red sesquioxide was the primary condition of iron in red beds, rejecting Dr. Dawson's hypothesis that the sesquioxide was derived from the oxidation of bisulphide of iron under the influence of heat and moisture.

The bleaching of red beds and the pale blotches which so frequently occur in the midst of the primordial colour are invariably due to the abstraction of the colouring oxide, and in most cases appear to be entirely independent of any predisposing cause. The majority of examples of variegation in which there are neither mechanical nor segregated nuclei present, exhibit no differences in the light and dark parts, merely as regards the *proportion* of iron present, neither is there any change in the composition of the matrix, nor any alteration in the state of combination, except the invariable conversion of the red anhydrous into the hydrous sesquioxide. Of variegation in connection with joints or cracks, there are two distinct forms: one connected with surface infiltration, in which, along the line of joint, beds containing carbonate of protoxide of iron have become charged with the apparently insoluble sesquioxide; and the other, in which rocks coloured by the red sesquioxide have become bleached by its conversion into the protoxide.

The generally accepted theory, suggested by De la Beche, of the bleaching power of fossil carbonaceous matter by its reducing action upon the colouring oxide is not considered sufficient by Mr. Maw. Analyses lead to the conclusion that in these cases variegation results from a rearrangement of the iron, and not from its loss in a soluble condition, and that this rearrangement sometimes takes place centripetally and at others centrifugally.

The cause which has produced the banding of yellow sandstone seems to have been that instead of the hydrous peroxide of iron accumulating in spherical nuclei, the segregation has taken place in lines which have gradually advanced, gathering up the peroxide in their progress, and leaving behind them the bleached sandstone deprived of its iron.

The conclusions at which the author has arrived are that a very *small proportion of the forms of variegation can be accounted for by the mere altered state of combination of iron, in situ,* the alterations of the red anhydrous sesquioxide into hydrous sesquioxide, the reduction of sesquioxide to protoxide of iron, and occasionally the change of colour due to the decomposition of bisulphide of iron, completing the list of colour alterations due to a merely chemical change. Neither will the presence of organic matter account for the changes; and the author concludes that the transference of the colouring matter has taken place by the simple mechanical agency of segregation, principally, and also by infiltration and dissolution.

A paper by Dr. Leith Adams announces the discovery of the Asiatic elephant in a fossil state. The tooth, upon which the determination is based, was found by Dr. Duggan, at a distance of over forty miles from the sea-shore, between Kanagawa and Jeddo, in Japan, and at the base of a surface coal-bed. Mr. Busk, to whom Dr. Adams sent a plaster-cast of the specimen, considers it to be the antepenultimate upper left molar of what, if met with in the recent condition, he should undoubtedly refer to *Elephas Indicus.* The principal points of difference between the specimen in question and the similar recent molar, are its considerable curvature, its somewhat greater proportionate breadth, and the greater thickness of the plates. These differences, however, are unimportant, and there is every reason to believe that the Japanese fossil tooth belongs to a form of *Elephas Indicus*, with teeth somewhat larger than the average of the existing one.

In a paper by Dr. F. Stoliczka, "On Jurassic Deposits in the North-west Himalaya," the author combats the statement of Mr. Tate that he has failed to establish a true correlation between the Jurassic stages of the rocks of the Spiti valley and their European equivalents, which are all distinguishable by the characteristic fossils of their European analogues. Dr. Stoliczka has distinguished the following formations:—

1. Lias	*a.* Lower Tagling Limestone.
	b. Upper Tagling Limestone.
2. Dogger	*c.* Jurassic slates (not specified).
	d. Spiti shales.
3. Malm?	*e.* Gieumal sandstone.

The Lower Tagling limestone generally rests unconformably on the Lower or Upper Triassic limestone, while the Gieumal sandstone is overlain by Cretaceous rocks. Supposing the determination of the species to be correct, and Dr. Stoliczka is too good a palæontologist to make the matter doubtful, there can be no doubt that he has succeeded in proving that the Himalayan Jurassic rocks can be separated into determinate stages.

In a paper "On the Distribution of Stone Implements in Southern India," Mr. R. Bruce Foote describes the occurrence and position of the quartzite implements which are found in the laterite deposits of the eastern coast. These deposits, which are considered to be of marine origin, occupy the position of a belt, eight to ten miles in width, running parallel with the general coast line, and broken through by the different rivers running into the Bay of Bengal. This belt has been examined only from Ongole to Tanjore, a distance of 300 miles; but Mr. Foote states that it extends southward from the latter place, nearly down to Cape Cormorin, and on the north will probably be found to join the laterite of Orissa. The depth below its present level, to which

the land was depressed, at the time of the formation of the lateritic deposits, would appear to have been very great. Laterite, containing implements, occurs at a measured height of 370 ft. above mean sea-level; and the author has found in the Alicoor hills several implements at a height of what could not have been less than 500 or 600 feet above the level of the sea.

Other implements have been discovered lying on the surface of the country, but at such great elevations (1400 feet) as to preclude the idea that they came from beds of marine origin. Mr. Foote considers that these were once enveloped in freshwater deposits, which have been removed by denudation. The quartzite pebbles, from which the implement makers drew their supplies to chip the various tools, came from the Jurassic conglomerates, which form the adjacent hills. These hills were probably islands standing up in the midst of the laterite sea, and were the homes of the manufacturers of the weapons and tools. The absence of any organic remains in the laterite precludes, however, the possibility of arriving at a satisfactory conclusion as to its age.

Dr. Holl, in a paper "On the Older Rocks of South Devon and East Cornwall," describes in great detail the extension and stratigraphical relationship of the different beds which lie to the south of the Carbonaceous rocks of Central Devon, and the adjacent parts of Cornwall. Neither the highest nor the lowest part of the Devonian system as seen in North Devon occurs on the south side of the Culm Measures, between which and the underlying Devonian there is a complete unconformity. The author divides the rocks of the district into three groups: Lower, Middle, and Upper South Devon groups. Of these the lower group extends from Dartmoor, by Hingston Down, to the Brown Willey granite, and may possibly be correlated with the base of the Ilfracombe group of North Devon. The discontinuous calcareous range of the Looe River, St. Germans, Brickfortleigh, Ashburton, and Bickerton, with the overlying slates, which separate it from the Plymouth and Torbay range, constitute the middle group. The upper group comprises the argillaceous slates, micaceous schists, and grits of Blagdon Cross and Kingsbridge promontory, and probably corresponds to the upper and Morthoe portions of the Ilfracombe series of North Devon.

8. METEOROLOGY.

The importance of the science of Meteorology is daily becoming more and more recognized; and its value to ourselves especially, as a maritime nation, is so great that we purpose henceforward to

include it among our Chronicles. We shall commence by giving a brief account of the work which has been completed, both at home and abroad, during the past year, and of that which is now in progress.

Our own Meteorological Office, under the management of the Committee of the Royal Society, is now fairly afloat, and its first Annual Report was presented to Parliament in July last. The Report consists of two parts, of which one gives an account of the work of the office in London, under Mr. Scott, assisted by Capt. H. Toynbee as Marine Superintendent; while the other is a full description, with plates, of the self-recording instruments furnished by the Committee to their newly-established observatories. These latter are seven in number, *viz.* Aberdeen, Armagh, Falmouth, Glasgow, Stonyhurst, and Valencia, with the observatory of the British Association at Kew, under the management of Dr. Stewart, as the central and normal one.

The price of this Report is so extremely low (1*s.*) that we must refer our readers to its pages, and shall only notice it very briefly.

The work of the office is divided into three heads, *viz.* Ocean Meteorology, Telegraphic Weather Intelligence, and the Land Meteorology of the British Islands.

As to the first, the Committee have resolved to complete the discussion of the materials left in an unfinished state by Admiral FitzRoy and Mr. Babington, and, as a commencement of new work, to employ the energies of the office on the investigation of the meteorological conditions of the district lying between the trade-winds in the Atlantic Ocean.

From this inquiry, which will necessarily be a tedious one, owing to the immense arrear of observations to be worked up, it is hoped, as General Sabine, the chairman of the committee, states in his last presidential address to the Royal Society, to ascertain the "conditions of atmospherical pressure, temperature, and vapour tension, the direction and force of wind, the character of weather, and the sea-surface temperature," for each month and for each square degree over the area under discussion. Meanwhile, the co-operation of several of our leading ocean steamship companies has been obtained, and thereby a staff of observers of a very high class has been secured.

"Telegraphic Weather Intelligence" is the term applied by the committee to the system adopted in lieu of the old storm warnings. In June, 1867, they proposed, in answer to the request of the Board of Trade, to organize a system of telegraphy of *facts*, instead of *prophecies* or *forecasts*, and thereby to revert, for the present, to what had been originally contemplated when "storm warnings" were first instituted. At the end of the year, when the whole of the reporting stations had been visited, the arrange-

ments were completed and the system was set in action. At present, General Sabine, in the address above quoted, informs us that the drum signal is hoisted at ninety-seven British stations, as well as at Hamburg and Cuxhaven; while telegraphic information of storms is also sent to Holland, and to the Ministry of Marine in France.

The first of the new observatories only commenced operations at the beginning of the present year, and we hope that ere long some results from these magnificent instruments may be communicated to the public.

The only other result of the work of the office which has as yet appeared has been a report by Mr. Scott, "On the Connection between Strong Winds and Barometrical Differences," which has been printed.

The inquiry was undertaken with a view of testing, by independent investigation of the weather reports published in 'The Times' for the period of nine months, the truth of the rule for foretelling the direction of the wind proposed by Professor Buijs Ballot. The rule has been very constantly brought before the public of late. It may be thus stated:—

Stand with your back to the wind, and the barometer will be lower on your left-hand side than on your right.

Accordingly if on any day the reading at Valencia is lower than that at London, we may expect southerly winds.

The report shows that strong winds are foretold correctly as to *direction* nine times out of ten, and as to both *direction* and *force* six times out of ten. It is shown that in the case of our great storms 90 per cent. of them gave unmistakable signs of their approach (in accordance with the rule) at least a few hours previous to their commencement. Serious storms never blow unless there be a considerable difference of atmospherical pressure within a limited area.

The results of the inquiry are fairly satisfactory, as a steady, though slight, advance in the direction of placing the study of weather on a firm scientific basis.

A notice of the pilot charts for the Atlantic, which have just been published by the Hydrographic Office of the Admiralty, is necessarily postponed.

In France, the magnificent series of charts—'Atlas des Mouvements Généraux de l'Atmosphère,' 1864, June to December, which has been issued by M. Le Verrier, next claims our notice. This consists of daily synoptic charts of the Atlantic Ocean from the equator to lat. 70° N., including, in addition, Europe and a few stations on the south and east coasts of the Mediterranean, and on the Atlantic seaboard of North America. The charts are constructed on the type of those which appear in the daily 'Bulletin

International' issued by the Observatoire Impérial; and they give for 8 A.M. every day the conditions of pressure, wind, sea-disturbance, and character of the sky, which have been obtained from ships' logs and land observations. The materials have been partly procured by the system of international co-operation; our own Meteorological Department and the Army Medical Department having contributed copies of observations furnished to them.

The value of a work like this for precise inquiries depends on the accuracy of the data furnished on the charts; and in this important particular we regret to say that the present Atlas leaves something to be desired.

It is naturally quite impossible to ensure absolute synchronism in the observations themselves, when the observers are scattered over so extended an area. Recourse must therefore be had to methods of interpolation, so as to reduce the results to what they would have been at 8 A.M. Paris time. This necessarily introduces a very serious amount of uncertainty. As regards the graphical representations, the isobaric lines have been drawn with a very free hand. In the preface M. Le Verrier says: "In the determination of isobaric curves the consideration of the winds is most important. They indicate to us the modifications which the curves undergo in the process of bringing themselves into harmony with each other, and explain to us sinuosities and irregularities which seem at first sight to have no apparent cause." Such an admission as the foregoing does away with the scientific value of these curves altogether. How is it possible to deduce any relation between wind and barometrical pressure, when the wind itself has been already taken as an important element in the determination of the course of those curves? This is arguing in a very limited circle indeed. However, the observations themselves appear to have been entered on the charts with all possible care, considering the difficulty of the preliminary calculations. The preface contains a most interesting account of the gradual development of the various meteorological undertakings carried on by the Observatoire Impérial.

In addition to this Atlas, two other volumes have appeared under similar auspices, the 'Atlas des Orages,' 1865, and the 'Atlas Météorologique,' 1866. These have reference almost exclusively to the distribution of thunderstorms and of hail over France during the years to which they respectively refer. The entire series of charts is most beautifully lithographed, and the whole is a valuable contribution to science.

Holland may take the next place, where the Royal Meteorological Institute at Utrecht, under the superintendence of Professor Buijs Ballot, assisted by Lieut. Cornelissen for the Marine branch, continues to work steadily, especially in the department of Ocean Meteorology. Owing to these publications being in Dutch, their

various contents are not as available as might be wished to most British readers. Accordingly we hail with great pleasure the announcement contained in the Report of the Meteorological Committee, that it is intended to publish shortly an English edition of the temperature charts for the South Atlantic Ocean which appeared in the work entitled 'Ondersoekingen met den Zee-Thermometer,' Utrecht, 1861 (Researches with the Sea Thermometer). This year the attention of M. Cornelissen has been directed in a special way to the sea-surface temperature round the south point of Africa, where the alternations of cold and warm water are so frequently noticed—the domain of the dangerous gales of those seas. We are glad to say that this work has been published in English. It contains charts giving the temperature for each square degree during the different seasons, which are of great interest and value.

With regard to the land-work of the Institute, the Jaarbock (Year-book) has now reached its nineteenth annual volume.

In Prussia Professor Dove has brought out during the last two years the results of the monthly means of the meteorological elements for the four years 1864–67, with the five-day means of temperature, obtained by the discussion of the observations furnished by the Meteorological Institute, and also the first portion, relating to temperature, of a research into the climatology of North Germany for the last twenty years. The preface to this work contains much interesting information: we learn from it that the number of stations in connection with the Institute has now reached 160, and as the instruments have all been repeatedly verified, the data derived from them are to be thoroughly trusted. It is, however, very satisfactory to hear from Professor Dove, the highest living authority on the subject, that having compared carefully the results furnished by the present system with those obtained in previous years, before the Institute was in existence and consequently before the regular verification of the instruments had commenced, he finds that the conclusions yielded by the older materials are very slightly different from those now in process of deduction. The works in question, like the former ones of the Institute, have appeared as a portion of the publications of the Royal Statistical Bureau, and compose Nos. 12, 14, and 15 of that series.

North Germany is also commencing the work of Ocean Meteorology, and an office, entitled the Nord-deutsche Seewarte, has been established at Hamburg, under the superintendence of Herr W. von Freeden, formerly Rector of the Navigation School at Elsfleth, near Bremen. In fact the entire organization is to a great extent due to the energy of the Director, whose long experience of similar investigations leads us to cherish the best hopes for the success of the new undertaking.

In Norway Professor H. Mohn has recently furnished a number

of stations, principally lighthouses, lying along the extended coast-line of that country, with instruments. Six of these possess telegraphic communication with Christiania. The organization of this system was commenced with the year 1867, and it is in connection with the Meteorological Institute of Norway, which, in itself, is affiliated to the University of Christiania. In addition to land observations, the Norwegian Marine has been solicited to take part in the work, and many of the sea-going captains have most cordially agreed to keep Meteorological Registers.

In Russia, and indeed in the world at large, Meteorology has sustained a most serious loss in the death of Professor Ludwig Kaemtz at the end of the year 1867. He had been only for two years Director of the Central Physical Observatory, having been appointed to that post on the death of Kupffer. The vacant position has since been filled by the appointment of Professor H. Wild, formerly at the head of the Observatory at Berne.

In Austria the K: K: Anstalt für Meteorologie und Erdmagnetismus has published the third volume of the new series of its Jahrbuch, being the results for 1866. Dr. Carl Jelinek, the Director of the Institution, tells us that the number of stations in connection with it has increased to 141. The volume is enriched by a most valuable paper by Professor Karlinski on the mean temperature of Cracow as deduced from forty years' observations.

Austria is also lending a hand to the work of Marine Meteorology, and has invited the co-operation of its own Navy and Merchant service.

In Italy the death of Matteucci has been a most unfortunate check to the development of meteorological organization, for although Secchi and others continue to issue their several publications, individually of great importance, there is as yet no central body under whose auspices these separate labours might be combined into a harmonious whole. This most desirable consummation seems sufficiently distant, but we may venture to express the hope that it will sooner or later be realized.

The result just alluded to was brought about in Switzerland in the year 1863, by means of a Meteorological Committee appointed by the Swiss Natural History Society. The system now comprises eighty-two stations, within a small area, but varying in their elevation above the sea, between 700 and 7600 feet. The Meteorology of Switzerland, and more particularly the question of the origin of the "Föhn," or south wind, whose action often causes such serious damage by floods, has been of late the theme of a warm controversy, and it may be hoped that the efforts now being made will help to elucidate this problem.

Our space will not allow of more than a passing reference to other countries, but we hear of meteorological organization in Den-

mark and also in Turkey, while the veteran Quetelet at Brussels, Aguilar at Madrid, and Capello at Lisbon, continue to publish the results of their respective observations.

Leaving Europe, we are glad to see that the United States are resuming the work suspended during the war, so that we may hope ere long to receive from the other side of the Atlantic valuable contributions in continuation of the work so energetically carried on in former days by Maury.

In our colonies the subject is generally attracting attention. The Government of Bengal has established a Meteorological office at Calcutta, of which Mr. H. F. Blanford has undertaken the superintendence, and has announced his intention of working at the meteorology of the Bay of Bengal. A system of storm warnings has also been set on foot.

The palm, however, of all work in those regions belongs to the Meteorological Society of the Mauritius, whose secretary, Mr. Charles Meldrum, is now in England, and engaged in the preparation of synoptic weather-charts for the Indian Ocean. Mr. Meldrum has read several valuable papers before various societies since his arrival in Europe, a notice of which must unavoidably be postponed.

We regret also to be unable on the present occasion to refer to the proceedings of the Meteorological Societies both in this country and in France, and can only hope hereafter to revert to the valuable researches contained in their journals.

9. MINERALOGY.

(With Notices of Recent Mineralogical and Petrological Works.)

To trace the progress of Mineralogy, quarter by quarter, would in truth be a cheerless task if the chronicler were restricted to the work that is carried forward in our own country. So little energy is brought to bear upon the study of British mineralogy, that many a month may pass without the publication of a single memoir worthy of being placed on record. Happily this state of lethargy has not extended to the Continent. There indeed scientific activity, not less in this department than in others, remains as rife as ever. In the periodical literature of continental science, Mineralogy occupies a position to which it is fairly entitled by its importance, but from which it is sadly degraded in this country. Hence it is, that the records regularly published in this Journal often contain so much about mineralogy abroad, but so little about mineralogy at home. As an introduction to the notes which we are about to offer in the present number, such an apology seems especially needful.

In a paper "On the Distribution of Microscopic Nepheline,"* Dr. Zirkel shows that this mineral, which a few years ago was regarded as peculiar to an exceedingly limited number of rocks, really enjoys a very wide-spread distribution, but that its crystals are in general so minute as to escape detection without microscopic aid. Nepheline usually occurs in six-sided prisms, and therefore its sections will appear as hexagonal or as rectangular plates, according as the crystals are cut transversely or longitudinally; whilst the rectangular sections will be either oblong or square, according to the height of the prism. When pure, nepheline is clear and colourless, but the larger crystals are usually more or less tinted by the presence of numerous grayish particles exceedingly minute, and variously disposed within the substance of the mineral: such particles are often accumulated in the centre of the crystal, and surrounded by a pellucid zone. When cut parallel to the principal axis of the prism, the sections often exhibit long lines of particles running in a longitudinal direction; and many of the crystals are also penetrated by tiny needle-like prisms of green augite. In microscopic examination, the observer must beware of mistaking crystals of apatite for those of nepheline, since the two minerals assume somewhat similar forms.

Having thus established the characters of microscopic nepheline, Zirkel proceeds to trace its distribution. Among the principal rocks in which he has detected it, may be mentioned the hornblende-andesite of the Wolkenberg and other hills of the Siebengebirge on the Rhine; the sanidine and oligoclase trachyte which forms the well-known "castled crag of Drachenfels"; the similar trachytes of the Cantal in Central France; the famous domite of the Puy-de-Dôme; and many of the trachytes and andesites which form so marked a feature in the geology of Hungary and Transylvania. It has long been supposed that certain basalts may contain nepheline, but Zirkel converts this supposition into a certainty: its presence in such rocks is however difficult to determine, and the sections need to be carefully prepared. Our Scotch geologists may not be aware that the greenstone of Arthur's Seat is remarkably rich in well-formed crystals of nepheline. Nor must it be supposed that the presence of this mineral is confined to rocks of any particular geological epoch, since it is found equally in the youngest eruptive rocks and in the oldest melaphyres.

Two new Silesian minerals have recently been described by Dr. Websky, of Breslau.† One of these is named, from its locality, *Kochelite*, whilst the other is to be called *Sarcopside*, in allusion to

* 'Ueber die Verbreitung mikroscopischer Nepheline.' Leonhard und Geinitz's 'Neues Jahrbuch für Mineralogie,' u.s.w. 1868. Heft VI., p. 697.

† 'Ueber Sarkopsid und Kochelit, zwei neue Minerale aus Schlesien.' Zeitschrift d. Deutsch. Geolog. Gesellschaft. 1868. Heft II., p. 245.

its resemblance to muscular tissue. Kochelite occurs as a brownish-yellow incrustation, with a columnar structure, investing titanic iron-ore and fergusonite. Its analysis, which is extremely complex, points to its chemical relations with yttrotantalite. The second mineral, Sarcopside, occurs in ellipsoidal masses invested with vivianite and embedded in granite. Internally these nodules exhibit a complicated structure, being made up of a reticulated arrangement of thread-like crystals, varying in colour from lavender to flesh-red. It is essentially a phosphate of iron and manganese, its analysis leading to the following unattractive formula:—

$$3\,PO_5\,(2\,Fe\,O, Mn\,O) + PO_5\,(2\,Mn\,O, Ca\,O) + Fe\,Fl + Fe_2\,O_3, HO.$$

For some years past extensive deposits of potash-salts have been worked in connection with the rock-salt of Stassfurt, in Prussian Saxony. Among these potash-salts—so valued by the agriculturist as fertilizing agents—the chloride of potassium in a compact state has long been found, and has passed under the various names of Leopoldite, Schätzellite, and Hovelite. *Sylvine* is, however, the mineralogical name by which the pure chloride is best distinguished. Of this mineral some splendid crystals have lately been found lining large drusy cavities in the Stassfurt deposits. The crystals—of which some of the faces measure a couple of inches across—are combinations of the cube and octohedron, and exhibit a perfect cubic cleavage. In appearance they strongly resemble rock-salt, but are distinguished by a somewhat sharper taste. Although usually colourless, they are sometimes tinged red, either by mechanical enclosure of oxide of iron, or by the presence of a gaseous substance, probably marsh-gas. The crystals are almost pure potassium chloride, containing only a small percentage of the chlorides of sodium and magnesium, with traces of the sulphates of soda and magnesia. A notice of the mineral has been laid before the German Geological Society by Herr Huyssen.*

Availing himself of these crystals of sylvine—unparalleled as they are for size and transparency—Professor Magnus has been enabled to examine the effect of chloride of potassium on radiant heat.† He finds its behaviour to be precisely similar to that of the analogous sodium compound; both minerals being highly diathermanous, irrespective of the temperature of the source of heat. Sylvine is thus entitled to share the appellation hitherto enjoyed solely by rock-salt—that of "the glass of radiant heat."

Mr. J. R. Gregory has just returned from a mineralogical tour in South Africa, having been commissioned by Mr. Harry Emanuel,

* Zeitschr. d. deutsch. geolog. Gesellsch. 1862. Heft II., p. 460.
† 'Comptes Rendus,' 1st Sem., No. 26, p. 1302; 'Phil. Mag.,' Oct. 1868, p. 320.

the well-known jeweller, to examine the reputed diamond districts of that country.* As the rocks which he traversed were for the most part amygdaloidal traps, it is highly improbable that they would ever yield diamonds or other gems; and hence he concludes that the alleged discoveries are purely deceptive, all the stones exhibited as Cape diamonds having been previously imported from other countries. Mr. Gregory also hints that the African *El Dorado* is equally visionary. That gold exists in South-eastern Africa, every traveller admits; but that it exists in quantity sufficient to render its working remunerative, Mr. Gregory is evidently inclined to doubt. It is only just to add that an attempt has been made to refute these statements, tending, as they so inevitably do, to the prejudice of the colony.†

Although Mr. Gregory brings home neither diamonds nor gold-dust, some of his South African specimens are not without interest. One of these is a meteorite, weighing 2 lbs. 5 oz., which fell on the 20th March, 1868, at Daniel's Kuil, Griqua territory. Its fall was witnessed by a native Griqua, who picked it up whilst still warm. In composition it is a meteoric stone, through which much free iron is disseminated, in association with troilite, schreibersite, &c. As but few African meteorites are known, we give Professor Church's analysis of this stone.‡

Nickel-iron	29·72
Troilite	6·02
Schreibersite	1·59
Silica and Silicates	61·53
Oxygen, other substances, and loss ..	1·14
	100·00

A new mass of meteoric *iron* from South Africa is also noticed by Mr. Gregory. It fell in 1862 at Victoria West, and is now exhibited in the Museum at Cape Town.

Some interesting questions are suggested by Kenngott's study of a Swiss specimen of limestone, which exhibits a drusy cavity containing gypsum and anhydrite. As it can hardly be supposed that these two minerals—the one hydrous and the other anhydrous—were of contemporaneous formation, it becomes a point of interest to determine which of the two was the earlier formed. Kenngott, after a lengthy discussion, concludes that the cavity was first filled with anhydrite, from which the gypsum has been derived by hydration.§

Under the euphonious name of *Aquacreptite*, Professor Shepard describes a massive mineral found at West Chester, Pennsylvania.‖

* See 'Quart. Journ. of Science,' Jan., 1868, p. 107.
† 'Journal of the Soc. of Arts,' Nov. 13th and 20th, 1868.
‡ 'Geolog. Mag.,' Nov., 1868, p. 532.
§ 'Neues Jahrbuch.' 1868. Heft V., p. 577.
‖ 'Silliman's American Journal,' Sept., 1868, p. 256.

In external characters it resembles the Tuscan miemite, but in composition it is a hydrous silicate of magnesia, iron, and alumina. Its name is suggested by the decrepitating sound which the mineral emits when thrown into water, especially if the liquid be warm.

The Professor also calls attention to a new meteorite which has been ploughed up on a farm near Losttown, Cherokee County, Georgia.* It weighs 6 lbs. 10 oz., contains abundance of nickel, and when etched exhibits the "Widmannstättian figures."

Perhaps the chemist, rather than the mineralogist, will be interested in a paper by Mr. J. E. Reynolds,† in which he attempts to introduce a new mode of expressing symbolically the chemical constitution of the mineral silicates,—a mode which he conceives to be free from the objections which may fairly be urged against the notations recently introduced by Odling, Frankland, Dana, and others.

Signor Bombicci describes, among other Italian minerals, a new calcareous serpentine to be called *Barettite,* after its discoverer Baretti; and an impure allophane remarkable for containing lead, and hence named *Plumboallophane.*‡

Many analyses of the triclinic felspars, labradorite, and oligoclase, have been published by Herr König, of Freiberg.§ The chemical examination of some Italian augites will be found in a recent memoir by Vom Rath.‖

Rammelsberg has published a paper on the composition of apophyllite and okenite,¶ and another on the phonolite of Mont Dore.** Finally, we may mention that Dr. Sandberger announces the discovery of tridymite in the trachyte of the Drachenfels.††

New Works on Mineralogy.—It has been well said that over the portals of Mineralogy might fitly be inscribed the famous motto placed by Pythagoras at the entrance to his school of philosophy, "Let no one enter here who is ignorant of Geometry." Indeed, to master the difficulties of crystallographic science, which early beset the path of the mineralogical student, a fair acquaintance with solid geometry is imperatively demanded; whilst the study of some of the more refined systems would be undertaken in vain without the assistance of spherical trigonometry. Every one, however, does not fall in love with

"The hard-grained Muses of the Cube and Sphere;"

and hence it can hardly be expected that crystallography will

* 'Silliman's Journal,' Sept., 1868, p. 257.
† 'Phil. Mag,' Oct., 1868, p. 274.
‡ 'Atti della societa ital. di scienze nat.,' XI.
§ Zeitsch. d. deut. Geol. Gesell. 1868, p. 365. ‖ Ibid., p. 265.
¶ Ibid., p. 441. ** Ibid., p. 258. †† 'Neues Jahrbuch,' 1868, p. 723.

ever become a popular study. Nevertheless, its value in the diagnosis of mineral species—a value recognized even by those who are least inclined to revert to the school of Mohs—should be sufficient to call for its assiduous cultivation on the part of all who are interested in mineralogical science. Crystallography is indeed nothing but the morphology of the mineral world; and the one is every whit as needful to the mineralogist as the other is to the biologist. To those, however, who take up the study of mineralogy, not for its own sake, but merely as an aid to the science of geology or to the art of mining, a very moderate knowledge of rudimentary crystallography is all that can be expected, or is indeed necessary. Such a knowledge may well be gained from the little 'Guide to Descriptive Crystallography,' recently written by Hochstetter and Bisching for special use in the study of mineralogy.* Issued without a preface, the work speaks for itself as an able and concise introduction to the science, which, though limited in its scope, is nevertheless sound and trustworthy. After a discussion of the general ideas which lie at the root of the science, the work deals in succession with each of the six "systems," or groups of related forms into which all crystals are capable of division, and treats of both the holohedral and hemihedral forms, together with the more important of their combinations. The system of notation employed throughout the work is that of Naumann, which still holds its ground as a favourite with most beginners; but as the book is published in Vienna, where Grailich's translation of 'Miller' is extensively read, it is not surprising that Miller's symbols are also given. The work is illustrated by a profusion of woodcuts, and indeed without ample illustration such a subject would be well nigh unintelligible.

Perhaps no mineralogical treatise enjoys a more extensive circulation as a text-book than Naumann's 'Elements.' The seventh edition of this work, enlarged and improved, now lies before us.† Of a book so well known little need be said. The first section contains an outline of crystallography, which is certainly not the least valuable part of the work. This is followed by a description of the physical properties of minerals, and an introduction to their chemical characters. The second part—which forms by far the larger portion of the book—is devoted to systematic mineralogy, and after some preliminary ideas on the principles of classification, proceeds with the physiography of species. As descriptive mineralogy advances, this part of the work

* 'Leitfaden der beschreibenden Krystallographie. Zum Gebrauche bei dem Studium der Mineralogie.' Von Dr. F. Hochstetter und A. Bisching. 8vo. Vienna, 1868, pp. 85.

† 'Elemente der Mineralogie.' Von Dr. Carl Friedrich Naumann. Siebente, vermehrte und verbesserte Auflage. 8vo. Leipzig, 1868, pp. 566.

necessarily increases in its proportions, and a glance at the index is sufficient to show that among the many new species—or reputed species—constantly being brought to light, there are but few that escape the notice of the great crystallographer of Leipzig.

A laborious compilation, by Dr. Websky, of Breslau, claims a passing notice as the first of a series of mineralogical monographs.* This is little else than a bald list of all the known mineral species, classified in groups according to their specific gravities, commencing with Pyropissite, which has a density as low as 0·493, and ending with Iridosmium, with a density as high as 21·2. The specific gravity is usually accompanied by the hardness, and sometimes by the chemical composition of the mineral. It is supposed by the author that the few characters here given will be sufficient to guide the student in the determination of species.

New Works on Petrology.—Probably it would be difficult to point to any branch of natural science which at the present time occupies a more unsatisfactory position in this country than that science which, according as it is pursued in the field or in the cabinet, has been variously designated *Petrology* or *Lithology*; in other words, the study of *rocks* as distinguished from that of *minerals*. Whilst we have pursued stratigraphical geology in a spirit worthy of the countrymen of William Smith, and have prosecuted the study of fossils with such vigour, and consequently with such success, that British palæontologists and their writings enjoy a world-wide reputation, it is strange that the complementary science of petrology should have fallen into unmerited neglect, and that in this department our best geologists should be found sadly wanting when weighed against their brethren of the hammer in other lands. Place, for example, the Journal of our own Geological Society by the side of the *Zeitschrift* of the corresponding German Society, and our shortcomings on this point are all too plainly seen. The geologist, therefore, who would describe with accuracy the rocks that are forced upon his observation in the course of his daily work, must needs betake him to the fields of continental literature, where the fertility that has been evoked by many a painstaking labourer strikingly contrasts with the sterility at home. Especially in the rich literature of Germany does he find no lack of treatises which exhibit that happy combination of chemical, mineralogical, and geological knowledge, without which the study of petrology would be next to impossible. Not to mention a host of minor writings, it is sufficient to point, in support of our assertion, to the admirable works of Senft and Zirkel. As a fit introduction to these compre-

* 'Die Mineral-Species, nach den für das specifische Gewicht derselben angenommen und gefunden Werthen. Ein Hülfsbuch zur bestimmenden Mineralogie.' Von Dr. Martin Websky. 4to. Breslau, 1868, pp. 170.

hensive treatises, it is our duty to call attention to a useful little work recently written by Dr. Kenngott, of Zurich.*

Those who are unable to wade through the larger volumes will here find an excellent outline of modern petrography. In the early chapters the author gives as much elementary mineralogy as he considers needful as an introduction to petrology. When we remember that it is to the want of mineralogical training on the part of most geologists that the backward state of petrology must mainly be referred, the propriety of such an introduction is at once evident. A chapter then follows on the general relations of rocks, in which are discussed their mineralogical constitution, physical structure, and probable mode of original formation and subsequent alteration. The writer then proceeds with the systematic description of the different species of rocks, and, without any pretence to originality, goes over much the same ground as is usually covered by the larger treatises. It should be remarked that in expressing symbolically the chemical constitution of rock-forming minerals, he introduces the new atomic weights, whilst he retains the old method of rational formulæ. The propriety of this seems questionable. Good geologists are, as a rule, bad chemists; and much confusion may therefore arise on comparing Kenngott's formulæ with those given in other mineralogical works. In dismissing the book, it is only necessary to notice its unusually full index—an index which in some measure plays the part of a supplement, inasmuch as it contains short descriptions of unimportant rocks which find no place in the body of the work.

Whilst Germany, without doubt, takes the lead in petrological science, France occupies a position far from discreditable, as amply testified by the writings of such men as Daubrée, Durocher, Coquand, and Delesse. Among her most ardent students must be numbered the late M. Cordier, who for more than a quarter of a century devoted himself to the study of rocks. At once an accomplished mineralogist and an experienced traveller, Cordier was well fitted to examine his specimens by the most minute and exact methods, while he was kept from those narrow generalizations in which the mere worker in the cabinet is too prone to indulge. His collection of rocks, now deposited in the Geological Gallery of the Museum of Natural History in Paris, numbers no fewer than ten thousand specimens, each said to represent a distinct variety! To classify this myriad of specimens with scientific accuracy was the great end of Cordier's life. Although mineralogical composition was the leading feature of his system, he was far from relying solely on any single characteristic—whether chemical, physical, mineralogical, geological, or genetic—

* 'Elemente der Petrographie, zum Gebrauche bei Vorlesungen und zum Selbststudium, bearbeitet von Dr. Adolf Kenngott.' 8vo. Leipzig, 1868., pp. 274.

but looking at the *ensemble* of these characters, he sought to establish a "natural" method of classification, following in the wake of Jussieu, and doing for petrology what has already been so ably done for botany. A description of his system has recently been published as a posthumous work, edited by his colleague, M. Charles D'Orbigny.*

The work is divided into three parts, in the first of which we learn the characters of rocks in general, the principles on which their species and varieties are founded, and the method followed in their classification. In connection with this section attention may be called to a chapter on the determination of compact volcanic rocks, which is the reproduction of an essay published as far back as 1815. The second part gives a systematic and detailed description of all the known rocks that compose the solid crust of the earth. In this section many new species are described, and one meets for the first time with such names as Harmophanite, Syenilite, Cristolite, Leucostite, Mimotalcite, Cecilite, &c. The third part contains some general considerations on the constitution of the earth's crust, and a description and classification of the crystalline rocks. Possibly the value of the book would not have been much diminished if this portion had been omitted, or at least considerably modified. As a testimony, however, to the practical value of Cordier's system of classification, the editor tells us that he has found by long experience that from fifteen to twenty lessons on this method are always sufficient to enable a student to determine a rock at sight, even when he commenced the study ignorant of the first principles of Mineralogy.

10. MINING AND METALLURGY.

Mining.

The shortness of the average duration of a miner's life has often been the subject of the most serious consideration. The Royal Commission, of which Lord Kinnaird was the chairman, made this portion of their inquiry a most searching one. It is clear, from the evidence given by medical men and others, that the metalliferous miner suffers in health from climbing on the perpendicular ladders from great depths, from working in air deficient in oxygen, and from the severe labour of boring holes for blasting in confined levels. The constrained position of the man in "beating the borer," and the muscular effort necessary to deliver the heavy blow, acts injuriously upon the heart and lungs. The miner has been relieved to

* 'Description des Roches composant l'écorce terrestre et des terrains cristallins constituant le sol primitif.' Ouvrage du feu P. L. A. Cordier, par Charles D'Orbigny. 8vo. Paris, 1868, pp. 553.

some extent from the effects of climbing by the introduction of the "man-engine" (a movable rod with platforms fixed upon it, by which the miner is gradually lifted—without fatigue to himself—from any depth to the surface). The ventilation of the mines generally has been improved, but it is only within the present year that any actual experiment has been made in the mines on the use of machines for boring holes, worked by compressed air or steam. We have been favoured, upon application, with the following report. We are glad to place this on record, as the commencement of an application of machinery to a most important purpose. We have no doubt that in a short time boring-machines will be generally adopted in our metal mines.

"Dœring's rock-boring engine has been worked on the 185 fathom level in Tincroft Mine, conjointly with another, from the 6th January up to the present time, and has driven sixteen fathoms in hard Tin Capel, which Captain Teague considers would cost 20*l.* per fathom if driven by hand-labour.

"During the greater part of this time, in consequence of the air-pumps getting constantly out of repair, the machine was only worked by one (shift) corps of two men; and continuous working with three corps, comprising five men and one boy, only commenced on the 6th July.

"Since this date nearly nine fathoms of ground have been driven, at a cost of 17*l.* 16*s.* 2*d.* per fathom.

"The following is the cost of working the machine during the last month:—

	£	s.	d.
Five miners and one boy	24	0	0
One boy to remove rubbish	2	0	0
Two enginemen at surface	6	0	0
One smith and boy	5	5	0
Oil, waste, and candles	3	9	0
Gun-cotton for blasting	4	10	0
Fuse	0	7	6
Sundries	0	3	0
Coals	6	0	0
Repairs	2	0	0
	£53	14	6

"In the above estimate the sum of 21*l.* 5*s.* is for expenses at the surface, which would be but slightly increased if three ends were driven instead of one—say about 2*l.* 15*s.* This would reduce the average cost per fathom to 13*l.* 9*s.* 10*d.*, instead of 17*l.* 18*s.* 2*d.*

"During these last three months one corps has been worked by one man and a boy, and the result has shown that they will drive as much ground with the machine as two men could do in the same time. (Signed) F. B. Dœring."

We find, during a recent visit to the Cornish mines, that the patentee is offering to contract for sinking shafts and driving levels

upon such terms as will, without doubt, induce many mine adventurers at once to close engagements with him.

General Haupt's machine for boring is about to be introduced into the lead mines of Swaledale, in Yorkshire; and Mr. Lowe's machine is in use in several large railway cuttings and tunnels.

The severe depression which has for the last two years pressed so heavily on copper and tin mines in this country is happily passing away. The prices of metals have improved, and hence the increased value of the ores. The demands for tin and copper are becoming more active. The imports of these metals have declined; hence the improved demand for British minerals. It should not be forgotten, however, that this state of things is not likely to last. South American copper-ores will soon flow into our markets, the countries producing them—Chili and Peru—having recovered from the disturbances which have of late interrupted every industry and impeded commerce. The East Indian tin will be imported in large quantities from Banca and Billaton as soon as the improved prices will yield to the Dutch adventurers a profit.

Our miners must, therefore, direct their attention towards the application of machinery, so as to economize in every direction—not merely in the subterranean mining, but in all the surface operations.

Necessity—the mother of invention—has already done much in this way; but there is yet ample room for very considerable improvement in the modes of working our mines, and in the methods of dressing the ores for the market.

In connection with this subject we may name—as we do with satisfaction—the increased desire on the part of the Cornish miners to avail themselves of the many advantages offered to them by the Science Classes of the MINERS' ASSOCIATION OF CORNWALL AND DEVONSHIRE. We learn that four classes are now in operation in the mining districts around Helston, in which sixty working miners are proving themselves apt students of Chemistry, Mineralogy, Geology, and Mechanics. One class of nearly thirty is no less actively engaged at Redruth, another in the mining parish of Gwennap, while a seventh has recently been formed in the northern portion of the important mineral district of St. Just. The advantages which must result from these classes will, ere long, be felt in the improvement of mining and in the elevation of the miners.

A report on the Mineral Statistics of Victoria has been recently published. From this report we glean the following particulars:—In 1859 there were 125,764 miners employed on the gold-fields; in 1867 there were only 63,053 so employed. The average earnings of the miners per man per annum have increased from 79*l.* 9*s.* 3*d.* in 1860 to 87*l.* 1*s.* 7*d.* in 1867. The mean of eight

years is about 76*l*. 1*s*. per man. Yet the "thirst for gold" leads men from all parts of the world to endure all the privations and the hardships of a gold-miner's life for this miserable reward. The value of the metals and minerals raised in the colony of Victoria since the discovery of the gold-field has been estimated as follows:—

	£
Gold, 33,910,052¾ oz..	135,643,811
Silver, 12,591 oz. 18 dwts.	3,460
Tin	195,045
Copper	4,673
Antimony	30,426
Coal, 1933 tons, at 1*l*. 10*s*. per ton	2,899
Lignite, 235 tons, at 17*s*. 6*d*. per ton ..	205
Kaslin, 1757 tons, at 4*l*. per ton	7,028
Flagging	18,663
Slates	508
Magnesite, 6¼ tons, at 2*l*. per ton	12
Diamonds, about 80 carats	80
Sapphires	150
Total value	£135,906,960

The quantity of gold exported in 1867 was 1,433,687 oz., of which 560,527 oz. were obtained from quartz veins, and 873,160 oz. from alluvial workings.

The explosions of fire-damp in some of the coal mines of France has naturally drawn attention to the subject of ventilation. M. Galy-Cazalat, who has brought the matter before the Académie des Sciences, proposes the construction of vertical air-pits, the purpose of which would be to draw off the carburetted hydrogen as rapidly as it is formed, and thus prevent its mixing with the air of the mine. These "*cheminées d'aspiration*," as he calls them, will scarcely require very special description, the whole plan really resolving itself into a greatly increased number of shafts, by which the air in every part of the mine may be rapidly changed. There can be little doubt that great advantages would arise from such a system; but in the large and deep collieries of this country there are many serious difficulties standing in the way of its introduction.

M. Delaurier has brought before the Academy of Sciences a plan for *destroying* fire-damp in coal-mines. He proposes to place copper conductors of considerable thickness in the galleries; these are to be broken at intervals, and united by means of very thin gold wire, which is to be covered with sulphur. By passing a strong current of electricity through those conductors, the sulphur is ignited, and if any fire-damp be present it will be fired. This idea is by no means new. The Academy is said to have spoken approvingly of the proposed plan; but all coincided in the opinion that regular and powerful means of ventilation could in no case be dispensed with. The combustion of the *fire-damp* would produce

choke-damp, which it would be necessary to remove. This plan, like many others which are from time to time brought forward, evidently originated with one who was but imperfectly acquainted with the conditions under which fire-damp is formed in a colliery.

The Pitch Lake of Trinidad ever and anon claims the attention of the public. At one time it is introduced as the source from which all the varieties of mineral oil, paraffine, and asphaltum can be obtained. At another period it is to be employed to give greater illuminating power to our coal-gas, and some experiments of the Hon. Captain Cochrane, made at Woolwich, were highly favourable. Now we have the pitch of Trinidad coming before us as an ingredient in artificial fuel for steamers. The bitumen is mixed with a certain quantity of charcoal; it is ground, and then made into bricks. Experiments made on board H.M.S. 'Gannet,' Commander Chimmo, appeared to show that it possessed many valuable properties, but the amount of ash, arising from the earthy matter mixed with the petroleum, was somewhat objectionable. This can, however, in all probability, be obviated by greater attention in the process of manufacture.

The Sicilian sulphur mines have been long known. More than 600 mines have been at work, and at least 200 worked out and abandoned. The mining is of the most primitive character, the use of machinery being extremely limited. Not less than 22,000 people are occupied in working those mines, and the result is the production of sulphur to the value of not less than 17,600,000 francs per annum. The sulphur ores of Spain are now largely imported into this country, and during the year not less than 500 tons of copper have been separated from sulphur-ash, after the sulphur has been expelled by burning, although the pyrites does not contain more than from 1 to 2 per cent. of that metal.

Metallurgy.

There is but little worthy of notice in the Metallurgy of the quarter, beyond the cheerful intelligence that in every branch there are evidences of a very decided improvement.

One process—that of Mr. Heaton—for the conversion of iron into steel, has been attracting considerable attention. Experiments have been in progress at Langley Mills, and the results are certainly of great promise. The process is conducted as follows:—Cast iron of any quality is first melted in a common iron-foundry cupola with coke fuel. A known quantity of the liquid iron—usually about a ton—is tapped out into an ordinary crane ladle, which is swung round to the side of the converter. This latter is a tall cylinder of boiler-plate, open at the bottom, between which and the floor a space is left. The converter has a fire-brick lining, and terminates in a conical covering, out of which an iron funnel opens to the

atmosphere. In the bottom of the converter a number of short cylindrical pots, lined with brick and fire-clay, are adjusted. Into these pots a given weight of crude nitrate of soda of commerce is put. The surface of the powder is levelled, and covered by a thick circular plate of cast iron. One of these pots thus prepared having been adjusted to the bottom of the cylinder, the converter is now ready for use. At one side of the cylinder is a hopper, covered by a loosely hinged flap of boiler-plate. This plate is raised, and the ladle full of liquid cast iron is poured into the converter, and descends upon the top of the cold cast-iron plate. The plate does not float up nor become displaced, nor does any action become apparent for some minutes, while the plate is rapidly acquiring heat from the fluid iron above it, and the nitrate getting heated by contact with it.

Professor Miller, of King's College, thus describes the process:—"In about two minutes a reaction commenced; at first a moderate quantity of brown nitrous fumes escaped; these were followed by copious blackish, then grey, then whitish fumes, produced by the escape of steam, carrying with it, in suspension, a portion of the flux. After the lapse of five or six minutes deflagration occurred, attended with a roaring noise and a burst of a brilliant yellow flame from the top of the chimney. This lasted for about a minute and a half, and then subsided as rapidly as it commenced. When all had became tranquil, the converter was detached from the chimney, and its contents were emptied upon the iron pavement of the foundry. These consisted of crude steel and of slag. The crude steel was in a pasty state, and the slag fluid; the cast iron plate had become melted up and incorporated with the charge of molten metal. The slag had a glassy blebby appearance, and a black or dark green colour in mass."

Professor Miller's report gives the following results of analysis of three samples of metal produced at the Langley Mills under his own observation:—

	Cupola. Pig (4).	Crude. Steel (7).	Steel Iron (8).
Carbon	2·830	1·800	0·993
Silicon, with a little titanium ..	2·950	0·266	0·149
Sulphur	0·113	0·018	traces
Phosphorus	1·455	0·298	0·292
Arsenic	0·041	0·039	0·024
Manganese	0·318	0·090	0·088
Calcium	..	0·319	0·310
Sodium	..	0·144	traces
Iron (by difference)	92·293	97·026	98·144
	100·000	100·000	100·000

"It will be obvious, from a comparison of these results, that the reaction with the nitrate of soda has removed a large proportion of the carbon, silicon, and phosphorus, as well as most of the sulphur. The quantity of phosphorus (0·298 per cent.) retained by the sample of crude steel from the converter which I analyzed is obviously not such as to injure the quality. The steel iron was subjected to many severe tests. It was bent and hammered sharply round, without cracking. It was forged and subjected to a similar trial, both at a cherry-red heat and at a clear yellow heat, without cracking; it also welded satisfactorily." The Professor concludes his report by stating that Heaton's process is based upon correct chemical principles, and that the mode of attaining the result is both simple and rapid.

Mr. Robert Mallet and Mr. David Kirkaldy have both made reports of the most favourable character upon this process and its results.

11. PHYSICS.

Light.—All the researches on this subject which have been published for some time past, have been thrown in the shade by some researches on a new series of chemical reactions produced by light, which have just been communicated to the Royal Society by Dr. Tyndall. He has investigated the action of a concentrated beam of light on vapours of volatile liquids, and has obtained some very striking phenomena of decomposition. A glass tube 2·8 feet long and of 2·5 inches internal diameter was supported horizontally. At one end of it was placed an electric lamp, the height and position of both being so arranged that the axis of the glass tube and of the *parallel beam* issuing from the lamp were coincident. The tube was closed by plates of glass; it was connected with an air-pump and also with a series of drying and other tubes used for the purification of the air. The experimental tube being exhausted and the cock which cuts off the supply of purified air being cautiously turned on, the air entered the tube bubbling through a liquid whose vapour was to be examined. The power of the electric beam to reveal the existence of anything within the experimental tube, or the impurities of the tube itself, is extraordinary. When the experiment is made in a darkened room, a tube which in ordinary daylight appears absolutely clean is often shown by the present mode of examination to be exceedingly filthy. The first experiment was tried with nitrite of amyl. The tube being exhausted, a mixture of air and vapour of nitrite were allowed to enter it in the dark, the slightly convergent beam of the electric light was then sent through

the tube from end to end. For a moment the tube was *optically empty*, nothing whatever was seen within it; but before a second had elapsed, a shower of liquid spherules was precipitated on the beam, thus generating a cloud within the tubes. This cloud became denser as the light continued to act, showing at some places a vivid iridescence. The effect was the same when the air and vapour were allowed to enter the tube in diffused daylight. The cloud, however, which shone with such extraordinary radiance in the electric beam, was invisible in the ordinary light of the laboratory.

When dry oxygen was employed to carry in the vapour, the effect was the same as that obtained with air. When dry hydrogen was used as a vehicle the action was also the same. The effect, therefore, is not due to any interaction between the vapour of the nitrite and its vehicle. This was further demonstrated by the deportment of the vapour itself. When it was permitted to enter the experimental tube unmixed with air or any other gas, the effect was substantially the same. Hence the seat of the observed action is the vapour itself. With reference to the air and the glass of the experimental tube, the beam employed in these experiments was perfectly cold. It had been sifted by passing it through a solution of alum, and through the thick double-convex lens of the lamp. When the unsifted beam of the lamp was employed the effect was still the same; the obscure calorific rays did not appear to interfere with the result. When, previous to entering the experimental tube, the beam was caused to pass through a red glass, the effect was greatly weakened, but not extinguished. This was also the case with various samples of yellow glass. A blue glass being introduced before the removal of the yellow or the red, on taking the latter away augmented precipitation occurred along the track of the blue beam. Hence, in this case, the more refrangible rays are the most chemically active.

When the quantity of nitrite vapour is considerable and the light intense, the chemical action is exceedingly rapid, the particles precipitated being so large as to *whiten* the luminous beam. Not so, however, when a well-mixed and highly-attenuated vapour fills the experimental tube. The effect now to be described was obtained in the greatest perfection when the vapour of the nitrite was derived from a residue of the moisture of its liquid, which had been accidentally introduced into the passage through which the dry air flowed into the experimental tube. In this case the electric beam traversed the tube for several seconds before any action was visible; decomposition then visibly commenced, and advanced slowly. The particles first precipitated were too small to be distinguished by a hand lens; and, when the light was very strong, the cloud appeared of a milky blue. When, on the contrary, the intensity was moderate, the blue was pure and deep. In Brücke's important

experiments on the blue of the sky and the morning and evening red, pure mastic is dissolved in alcohol, and then dropped into water well stirred. When the proportion of mastic to alcohol is correct, the resin is precipitated so finely as to elude the highest microscopic power. By reflected light such a medium appears bluish, by transmitted light yellowish; which latter colour, by augmenting the quantity of the precipitate, can be caused to pass into orange or red; but the development of colour in the attenuated nitrite-of-amyl vapour, though admitting of the same explanation, is doubtless more similar to what takes place in our atmosphere. The blue, moreover, is purer and more sky-like than that obtained from Brücke's turbid medium.

Space will not admit of our referring to the experiments made on iodide of allyl, iodide of isopropyl, hydrobromic acid, or hydrochloric acid; but the results obtained with hydriodic acid are of so startling and unprecedented a character that we consider it important to give them in Professor Tyndall's own words, as follows: "I have seen nothing so astonishing as the effect obtained on the 28th of October with hydriodic acid. The cloud extended for about 18 inches along the tube, and gradually shifted its position from the end nearest the lamp to the most distant end. The portion quitted by the cloud proper was filled by an amorphous haze, the decomposition which was progressing lower down being here apparently complete. A spectral cone turned its apex towards the distant end of the tube, and from its circular base filmy drapery seemed to fall. Placed on the base of the cone was an exquisite vase, from the interior of which sprang another vase of similar shape; over the edges of these vases fell the faintest clouds, resembling spectral sheets of liquid. From the centre of the upper vase a straight cord of cloud passed for some distance along the axis of the experimental tube, and at each side of this cord two involved and highly iridescent vortices were generated. The frontal portion of the cloud, which the cord penetrated, assumed in succession the forms of roses, tulips, and sunflowers. It also passed through the appearance of a series of beautifully shaped bottles placed one within the other. Once it presented the shape of a fish, with eyes, gills, and feelers. The light was suspended for several minutes, and the tube and its cloud permitted to remain undisturbed in darkness. On reigniting the lamp, the cloud was seen apparently motionless within the tube; much of its colour had gone, but its beauty of form was unimpaired. Many of its parts were calculated to remind one of Gassiot's discharges; but in complexity and, indeed, in beauty, the discharges would not bear comparison with these arrangements of cloud. A friend to whom I showed the cloud, likened it to one of those jelly-like marine organisms, which a film barely capable of reflecting the light renders visible. Indeed no other comparison is

so suitable; and not only did the perfect symmetry of the exterior suggest this idea, but the exquisite casing and folding of film within film suggested the internal economy of a highly complex organism. The *twoness* of the animal form was displayed throughout, and no coil, disk, or speck existed on one side of the axis of the tube that had not its exact counterpart at an equal distance on the other. I looked in wonder at this extraordinary production for nearly two hours."

It will be remembered that six or seven years ago Dr. Frankland communicated to the Royal Society some researches on the effect of a diminution of pressure on some of the phenomena of combustion, and deduced therefrom the law that the diminution in illuminating power is directly proportional to the diminution in atmospheric pressure. Further experiments on the nature of the luminous agent in a coal-gas flame have led him to doubt the correctness of the commonly received theory first propounded by Sir Humphry Davy, that the light of a gas flame and of luminous flames in general, is due to the presence of solid particles. It has been found that there are many flames possessing a high degree of luminosity, which cannot possibly contain solid particles, such as the flame of metallic arsenic burning in oxygen, which emits a remarkably intense white light; bisulphide of carbon in oxygen; and especially phosphorus in oxygen.

For these reasons, and for others which the author had stated in a course of lectures on "Coal-gas," delivered in March, 1867, he considered that incandescent particles of carbon are not the source of light in gas and candle flames, but that the luminosity of these flames is due to radiations from dense but transparent hydrocarbon vapours. As a further generalization from the above-mentioned experiments, he was led to the conclusion that dense gases and vapours become luminous at much lower temperatures than aëriform fluids of comparatively low specific gravity; and that this result is to a great extent, if not altogether, independent of the nature of the gas or vapour, inasmuch as he found that gases of low density, which are not luminous at a given temperature when burnt under common atmospheric pressure, become so when they are simultaneously compressed. Thus mixtures of hydrogen and carbonic oxide with oxygen emit but little light when they are burnt or exploded in free air, but exhibit intense luminosity when exploded in closed glass vessels, so as to prevent their expansion at the moment of combustion.

In a communication to the Royal Society, Dr. Frankland has described the extension of these experiments to the combustion of jets of hydrogen and carbonic oxide in oxygen under a pressure gradually increasing to twenty atmospheres. These experiments

were made in a strong wrought-iron vessel furnished with a thick glass plate of sufficient size to permit of the optical examination of the flame. The appearance of a jet of hydrogen burning in oxygen under the ordinary atmospheric pressure is well known. On increasing the pressure to two atmospheres, the previously feeble luminosity is very markedly augmented, whilst at ten atmospheres' pressure, the light emitted by a jet about one inch long is amply sufficient to enable the observer to read a newspaper at a distance of two feet from the flame, and this without any reflecting surface behind the flame. Examined by the spectroscope, the spectrum of this flame is bright and perfectly continuous from red to violet.

With a higher initial luminosity, the flame of carbonic oxide in oxygen becomes much more luminous at a pressure of ten atmospheres than a flame of hydrogen of the same size and burning under the same pressure. The spectrum of carbonic oxide burning in oxygen under a pressure of fourteen atmospheres is very brilliant and perfectly continuous.

If it be true that dense gases emit more light than rare ones when ignited, the passage of the electric spark through different gases ought to produce an amount of light varying with the density of the gas; and Dr. Frankland has shown that electric sparks passed, as nearly as possible under similar conditions, through hydrogen, oxygen, chlorine, and sulphurous anhydride, emit light, the intensity of which is very slight in the case of hydrogen, considerable in that of oxygen, and very great in the case of chlorine and sulphurous anhydride. On passing a stream of induction sparks through the gas standing over liquefied sulphurous anhydried in a strong tube at the ordinary temperature, when a pressure of about three atmospheres was exerted by the gas, a very brilliant light was obtained. A stream of induction sparks was passed through air confined in a glass tube connected with a condensing syringe, and the pressure of the air being then augmented to two or three atmospheres, a very marked increase in the luminosity of the sparks was observed, whilst on allowing the condensed air to escape, the phenomena were reversed.

Mr. Huggins, F.R.S., has submitted the light of Comet II., 1868, to spectroscopic examination, and has found it, when examined with a spectroscope furnished with two prisms of 60°, to be resolved into three broad bright bands.

The brightest band commences at about *b*, and extends nearly to F. Another band begins at a distance beyond F, rather greater than half the interval between *b* and F. The third band occurs about midway between D and E. In the two more refrangible of these bands, the light was brightest at the less refrangible end, and gradually diminished towards the other limit of the bands. The least refrangible of the three bands did not exhibit a similar grada-

tion of brightness. These bands could not be resolved into lines, nor was any light seen beyond the bands towards the violet and the red.

The author found this cometic spectrum to agree exactly with a form of the spectrum of carbon which he had observed and measured in 1864. When an induction spark, with Leyden jars intercalated, is taken in a current of olefiant gas, the highly heated vapour of carbon exhibits a spectrum which is somewhat modified from that which may be regarded as typical of carbon. The light is of the same refrangibilities, but the separate strong lines are not to be distinguished. The shading, composed of numerous fine lines, which accompanies the lines appears as an unresolved nebulous light.

On comparing the spectrum of the comet directly in the spectroscope with the spectrum of the induction spark taken in a current of olefiant gas, the three bands of the comet appeared to coincide with the corresponding bands of the spectrum of carbon. In addition to an apparent identity of position, the bands in the two spectra were very similar in their general characters and in their relative brightness. The remarkably close resemblance of the spectrum of the comet to that of the spectrum of carbon necessarily suggests the identity of the substances by which in both cases the light was emitted.

HEAT.—The intense heat of the voltaic arc has been applied by F. P. Le Roux in a most ingenious manner to heighten the brilliancy of the light, and at the same time to increase its steadiness. In applying electric light, the method generally proposed is to direct it into a more or less limited region of space; all which escapes into the opposite region would be lost if it were not collected by reflectors more or less appropriate to the purpose. On the other hand, experience has proved that the voltaic arc is prone to irregular displacements, consequent upon inequalities in the cohesion of the charcoal, impurities contained in it, and above all, the slightest agitation of the air. The most luminous portions of the charcoal electrodes being the surfaces between which the arc arises, these surfaces are inclined sometimes in one direction and sometimes in another, by reason of the displacement which the arc undergoes, the result being a considerable variation in the effect of light produced by the latter in any determinate region. M. Le Roux argued, in the course of his investigation, that if there could be placed on the opposite side to that towards which the light was to be directed, and in proximity to the arc, some body capable of reflecting back in a luminous form the enormous number of radiations thrown upon it by the electrodes and the arc itself, these radiations would be more profitably utilized than by any other method, the arc being

at the same time protected by a sort of screen, annulling in an almost hemispheric region all the above-mentioned disturbing causes.

The substance chosen for such a purpose should be at the same time a bad conductor of heat, and possessed of great powers of radiation, conditions fulfilled to a great extent by lime, magnesia, and earthy oxides in general. The experiment was first effected with cylinders of magnesia compressed according to the process of M. Caron, and manufactured for purposes of oxyhydric illumination. By placing the base of one of these cylinders, whose diameter is about 8 millimetres, at a short distance from the charcoal points of an electric lamp, in such a way that the magnesia may be, as it were, licked up by the voltaic arc, it will assume an incandescence equal to that of the most luminous portion of the charcoal. At the same time the light acquires remarkable constancy from the fixity of the arc, which may be drawn to greater length than in ordinary cases, because as the magnesia forms a screen and maintains the elevation of the temperature, the chances of the arc being broken are greatly diminished.

The magnesia may thus be kept in contact with the voltaic arc for more than an hour without sufficient consumption to cause any apparent change in the conditions of the experiment; its surface becomes hollow during the first few moments, but if the bar of this substance is kept fixed, the power of the arc abating at a very slight distance, it will no longer be consumed. Another kind of alteration will, however, ensue. The magnesia will imbibe the silicious vapours emitted by the voltaic arc, and combine with them in a sort of glass, which, when cold, is of a pale greenish hue, and extremely hard. This fact is disadvantageous, inasmuch as it greatly diminishes the irradiating power of the magnesia, and renders the production of a commercial pure carbon in an appropriate condition for the purpose of electric illumination still more desirable. The arrangement of a brilliant voltaic arc between two pencils of charcoal, and in the presence of magnesia or any other earthy oxide, would constitute one of the most beautiful sources of light possible to realize.

M. Kindt has made known the nature of the phosphorescence developed by heat in the three minerals, chlorophane, Estremadura phosphorite, and the green fluor spar. He has analyzed the light emitted: the first is a simple green; the second is a yellow-tinted light, composed of green, yellow, and red; and the third gives two black rays, the one in the green, and the other near the orange.

M. Becquerel has invented an electric pyrometer for the measurement of high temperatures. Metallurgists will probably find this application very advantageous. To solve the problem of the commercial application of a thermo-electric current as a pyrometer, it was necessary to make a thermo-electric couple with two unalterable

metals, resisting the highest temperatures, and then to establish a graduated table. As to the practical introduction of the pyro-electric couple, it is easily made. A table of sines has been specially constructed for these observations.

ELECTRICITY.—A new arrangement for furnishing currents of electricity has been made known by M. Ney. It is composed as follows:—1. A vessel filled with solution of chloride of ammonium, containing a plate of amalgamated zinc. 2. A porous cylinder filled with carbonate of copper, into which a plate of copper plunges. To maintain the battery in action, it is only necessary to add solid chloride of ammonium from time to time. In military telegraphy, where the pile should be capable of transport, the outer vessel might be filled with sand saturated with a solution of chloride of ammonium in the place of the solution. This arrangement recommends itself on the score of cheapness, for native carbonate of copper answers sufficiently well, and it likewise only requires attention while in actual use. Carbonate of copper is insoluble in a solution of chloride of ammonium, but upon closing the current, the chloride is decomposed into hydrochloric acid and ammonia; the hydrochloric acid collects at the zinc pole, the ammonia at the copper. The carbonate of copper becomes soluble, and its reduction gives rise to a secondary current having the power of a Daniells element. This form of battery is perfectly constant.

At a meeting of the French Academy some time ago, M. Sidot showed several samples of iron pyrites possessing magnetic polarity, obtained by passing a current of hydrosulphuric acid over the magnetic oxide. At that time he stated that the direction of the polar axis appeared to be in relation to the position of matters at the moment of their formation with reference to the magnetic axis of the globe. M. Sidot has now tested his supposition further by examining the behaviour of the magnetic oxide of iron, to ascertain whether it suffered the same physical modifications, when placed in the same conditions, as magnetic pyrites, and whether the polarity was produced by the earth by removing all causes foreign to terrestrial action. When a tube of refractory clay is placed parallel to the magnetic needle, in a furnace free from iron, and in the tube a platinum boat filled with colcothar, which is heated to bright redness in a current of air for an hour, the result, after cooling, is a strongly agglomerated grey oxide, possessed of magnetic polarity. The extremity of the oxide turned towards the north is a south pole; it energetically repulses the pole of a magnetic needle pointing to the north of the earth. A magnetic oxide is likewise obtained by calcining colcothar in a platinum crucible. The upper extremity of the mass presents a pole opposed to the south pole of the globe, and the lower extremity an opposite pole. To obtain masses possessed of greater magnetic polarity a different disposition was made.

A piece of iron plate in the form of a tube, was suspended in a clay tube placed vertically in a furnace traversed by a very rapid current of air, and heated to bright redness for the time necessary for the complete oxidation of the iron. Tubes of oxide were thus obtained possessed of magnetic polarity, and strongly repelling the poles of the magnetic needle. The polarity is always dependent upon the position of the iron plate. The magnet produced in this way was replaced in the furnace, reversed, and heated in the same conditions of temperature as before for one hour; after cooling, the poles were found to be reversed; that pole which is formed at the upper extremity is always similar to the north pole of the earth.

12. ZOOLOGY—ANIMAL MORPHOLOGY AND PHYSIOLOGY.

(Notices of Works recently published and Transactions of Societies.)

The alleged Failure of Natural Selection in the case of Man.—A writer in a recent number of 'Fraser's Magazine' endeavours to point out that although there is a struggle for existence of a more or less intense kind, between different *races* and *nations* of men, yet that between man and man in a civilized condition there is no such struggle—the weak being protected, and the feeble inheriting wealth which they have not won. Thus, the fittest do not survive contends this writer, and the law of selection is so far interfered with as to fail, and indeed we may expect degeneracy rather than improvement in civilized men. The 'Spectator,' in one of its clever articles—written, however, in this case with a hasty and mistaken idea of the question at issue—accepts the view propounded by the writer in 'Fraser' in part, but, making use of the mysterious term "*supernatural selection*," asserts that a new source of benefit is opened up to man by the cultivation of his moral nature, which counterbalances any attendant evils. The error in this view of the case arises from a neglect of the fact that civilized man is a social animal, in a truly zoological sense. There is no struggle for existence between the various bees of a hive, nor among polyps of a polypidom: the struggle is between hive and hive, and polypidom and polypidom. So with the communities of civilized men—the struggle is between one society and another, whatever may be the bond uniting such society: and in the far distant future we can see no end to the possible combinations or societies which may arise amongst men, and by their emulation tend to his development. Moral qualities, amongst

the others thus developed in the individual necessarily arise in societies of men, and are naturally selected, being a source of strength to the community which has them most developed: and there is no excuse for speaking of a failure of Darwin's law or of "supernatural" selection. We must remember what Alfred Wallace has insisted upon most rightly—that in man, development does not affect so much the bodily as the mental characteristics; the brain in him has become much more sensitive to the operation of selection than the body, and hence is almost its sole subject. At the same time it is clear that the struggle between man and man is going on to a much larger extent than the writer in 'Fraser' allowed. The rich fool dissipates his fortune and becomes poor; the large-brained artizan does frequently rise to wealth and position; and it is a well-known law that the poor do not succeed in rearing so large a contribution to the new generation as do the richer. Hence we have a perpetual survival of the fittest. In the most barbarous conditions of mankind, the struggle is almost entirely between individuals: in proportion as civilization has increased among men, it is easy to trace the transference of a great part of the struggle little by little from individuals to tribes, nations, leagues, guilds, corporations, societies, and other such combinations, and accompanying this transference has been undeniably the development of the moral qualities and of social virtues.

MORPHOLOGY.

The Early Stages of Development in Vertebrates.—Dr. Wilhelm His, professor at Basel, and a worthy pupil of the great pioneers of embryology, Rathke and Von Bär, has recently published a valuable work on the above subject, illustrated with twelve plates. The principal point upon which Dr. His insists is the presence of two germinal elements—the principal or primary germ, and the subordinate or secondary germ. From the first proceed the most essential tissues, *viz.* the nervous, muscular, and epithelial, whilst from the second arise the skeletal and nutrient structures, *viz.* connective tissues, cartilage, bone, and the vascular system. Dr. His traces out fully the development of each of these two portions, which he distinguishes in the early embryo, and describes how they grow the one into the other, eventually producing a most complex interlacement of parts. He also points out that the development of the secondary germ is very much affected by mechanical conditions, and endeavours to show how the form and relation of parts is thus brought about in the embryo. The perivascular lymph-spaces of the brain discovered by Dr. His are shown to arise from the intrusion of blood-vessels formed by the secondary germ into spaces

excavated in the primary germ. A comparison of the two extremities of the developing vertebrate is also made, and some curious similarities in opposite parts alluded to. Professor His is so distinguished an observer, that this volume cannot fail to command great attention both in this country and abroad.

New Species of Tasmanian Wolf.—Of all mammals there is perhaps not one existing which is so truly interesting, so deeply significant of the history of the development and geographical distribution of mammals, as the marsupial dog. Mr. Gerard Krefft, of the Australian Museum at Sydney, has lately obtained from his assistant, Mr. Masters, no less than twenty-six skulls of this rare animal, which is found only in Tasmania. Two of these skulls belong to a new species, distinguished by its shorter muzzle and other characters, for which Mr. Krefft proposes the name *Thylacinus breviceps.* The existence of a second Thylacine has been known to old residents in Tasmania for years past, as they were in the habit of distinguishing the two kinds by the names of greyhound- and bulldog-tiger. A fuller account of the collection of skulls is promised for a future number of the Annals of Natural History.

Transporting Fish alive.—Mr. Moore, the curator of the Liverpool Free Museum, has succeeded in importing some living fish from the River Plate, the first live fish that he has received from south of the Equator. Some English fish sent out by the same captain arrived safely, and he left Liverpool on the 10th of October with another series of fish. They were sent out and imported in a common fish-globe, suspended like a cabin-lamp in gimbals. There are now exhibited in the Liverpool Museum, two Catfish, three species of Pomotis, two of Cyprinus, four Axolotls, and a *Proteus*, that were imported from New York by the same method. Dr. Perceval Wright, on his return journey from the Seychelles last autumn, succeeded in bringing a small Cyprinoid, *Haplochilus*, as far north as Paris. He found that the motion in the railways was by far the hardest thing to contend with, and indeed his fish were absolutely jolted to death, the churning of the water preventing respiration.

Occurrence of the Ground-Fluke in England.—A soft dingily-coloured little creature, not an inch long and very much like a small slug, has lately excited a little attention by its discovery in England. Sir John Lubbock found specimens of it in his garden in Kent, and mentioned the fact to the Linnean Society in September last, and Mr. Houghton has seen it in Shropshire. Originally it was discovered by Müller in Denmark, and named by him; it has since been observed by Dugés in France, and by Fritz Müller, and Moll in Germany. In 1867, Mr. Ray Lankester drew attention to it in the 'Popular Science Review,' and expressed a belief that it would be found in England; shortly after this he received four living

specimens from Mr. Edward Parfitt, of Exeter. It appears that its occurrence in England had been recorded some years since by the Rev. Leonard Jenyns. Sir John Lubbock and Mr. Houghton say that this ground-fluke is a true *Planaria* Those, however, who have studied the Turbellarian worms will know that the genus *Planaria* must have a very much more restricted character, and cannot be made conveniently to include this form, for which the genus *Geoplana* is usually adopted. In South America and Ceylon there are other forms of land-flukes of larger size and very brilliant colour. The English species differs considerably from these, but its anatomical details are not known. It is almost impossible to dissect specimens, and they are not sufficiently transparent for the microscope. The ground-flukes, however, undoubtedly belong to that section of the short aproctous Turbellaria, in which the intestine is arborescent.

American Polyzoa.—Mr. Alpheus Hyatt has published, in the Proceedings of the 'Essex Institute' of Salem, Mass., a very detailed and valuable account of the fresh-water Polyzoa (Phylactolæmata) of that part of the North American continent. A large portion of the work is occupied with anatomical descriptions, which are illustrated in plates executed on a black ground; a style which appears to be a favourite one in the States, but which we think is very inferior to a well-shaded drawing of the ordinary description. Here is a statement which we assuredly cannot accept, "It therefore becomes necessary to alter the commonly received nomenclature, and to denominate the attached end of a Polyzoön the anterior, the free end the posterior, the anal side the dorsal, and the opposite or so-called hæmal side the ventral." It is not at all "necessary" to use the objectionable terms "anterior," "dorsal," and their converse, and they certainly can have no strict meaning, but only a conventional one. The term "Saccata" is proposed for the Mollusca, and has been endorsed by Mr. E. S. Morse in a paper on the classification of those animals. Saccata is not by any means an appropriate term; for the Infusoria, the Cœlenterata, and many worms are quite as distinctly sack-like as the mollusca, in fact, all animals are sacks. The following genera are described: *Fredericella* with three species, *Plumatella* with four species, *Pectinatella* with one species, *Cristatella* with one species. Many details of interest and importance are given in the anatomical descriptions of the genera; and the whole work is executed with very great care and methodical treatment.

The Glass-rope Sponge.—This interesting organism has, we think, at last come to the climax of its celebrity, and will soon sink into more or less of obscurity, for its secret has been discovered. Professor Lovén was right in supposing, from the study of a sponge

which he called *Hyalonema boreale*—but which should not be put in the genus Hyalonema—that the long tuft of glassy fibres constituting the so-called axis of *Hyalonema* is the pedicle by which it is fixed in the sea-bottom, and that the sponge grows on the top of this. Professor Perceval Wright, of Dublin, went last October to Lisbon for the purpose of dredging the European Glass-rope, discovered some two years since by Professor Barboza de Bocage, and he has succeeded in bringing it up from the deep sea-valley in which it grows in such a condition as to leave no doubt in his mind that it lives with the axis inserted in mud, as a sort of stalk. Dr. Carpenter and Professor Wyville Thompson too, on a recent dredging expedition off the west of Ireland, have brought up *Hyalonema* in the same way. Dr. Wright has no doubt that Max Schultze is right about the parasitic nature of the coral, which *sometimes* encrusts the axis of Hylomena, which is a true sponge. Dr. Gray, however, retains his opinion that the axis is the work of the coral, and that the sponge on the end of it is parasitic. In a recent article on a form of sponge allied to Euplectella (the beautiful crab's-nest sponge), which is really a close ally of Hyalonema, Dr. Gray points out that the long spicules in that form may possibly have been inserted in the mud as a support—as in Hyalonema, yet he still regards the one as sponge, the other as coral.

Physiology.

Intellectual Work and the Temperature of the Head.—Dr. J. S. Lombard, by means of an exceedingly delicate thermo-electric apparatus, has made some highly interesting experiments on the influence of cerebral activity on the temperature of the head. He finds: 1st. That in the state of cerebral repose (during night) the temperature of the head varies very rapidly and frequently. 2nd. The changes are very small, scarcely reaching the hundredth of a degree centigrade. 3rd. In proportion as the activity of the brain increases, the temperature is found to rise. 4th. Any cause attracting the attention (a sound, the sight of an object or a person) produces an elevation of temperature. 5th. Very active intellectual work produces a much more marked elevation of temperature than in the preceding cases. It does not, however, exceed a twentieth of a degree centigrade. 6th. An emotion, or reading aloud of anything of great interest, causes an elevation of temperature. It is not the movement of the heart or of the muscles which under these circumstances causes a rise in the temperature of the head. 7th. During very arduous intellectual work, the temperature of the limbs falls even as much as a quarter or half a degree centigrade; in

part, no doubt (but only in part), owing to the immobility of the body. 8th. It is in the region of the occipital protuberance that the elevation of temperature had its chief seat in the preceding experiments.

It will be interesting to consider the bearing of these phenomena on the Conservation of Force. It is apparently clear that intellectual activity—thought—is a force totally distinct from, although associated with, the mode of motion known as "heat," for both, it appears, increase in activity simultaneously. More than this it were not prudent to say at present, but it appears that here we have the first approach to a better understanding between the relations of "mind and matter," a subject upon which so much has been said speculatively, and so little done experimentally.

Effects of Rowing upon the Circulation.—Dr. Fraser, of Edinburgh, has been carefully examining the effects of rowing on the pulse, by means of the sphygmograph. Dr. Fraser had the opportunity of recording the "sphygmograms" of a crew of healthy men on several occasions, before leaving the boat-house and immediately after return. The tracings show clearly that an extremely large quantity of blood is being circulated with great rapidity—a condition of the circulation which would be considered essential on other grounds for the continuance of prolonged and severe muscular exertion. It is obvious that in the great majority of functional and organic diseases of the vascular system such a condition could not possibly be maintained. The subjects of these diseases are therefore completely incapacitated from *violent* rowing exercise, and cannot be in a position to be injured by it. It is possible that the presence of incipient forms of disease of the vascular system may not altogether prevent such exercise from being undertaken; but Dr. Fraser believes that all such diseases may be detected by the use of the sphygmograph in time to prevent further mischief, the examination being made immediately before the boat is entered, and a few minutes after a moderate pull has been indulged in. The effects produced by rowing on the circulation do not differ from those of many other forms of muscular exercise.

The Physiological Effect of Snake-bite.—Dr. Joseph Jones, of New York, has made some interesting observations on the effects of snake-bite. He used the American snake called the Copperhead, and subjected several dogs, at various times, to its bite. In some cases the dogs died; in others they recovered. In all cases Dr. Jones observed carefully the microscopical condition of the blood, and in cases of death made *post-mortem* examinations. Dr. Jones observes, in one case, "The blood from the swollen infiltrated cellular structures of the head and nose where the snake inflicted the severest bite presented a peculiar appearance: thousands of

small acicular crystals were mingled with the altered blood-corpuscles, and as the bloody serum and effused blood dried, the blood-corpuscles seemed to be transformed into crystalline masses, shooting out into crystals of *hæmatin* (hæmato-crystallin ?) in all directions. The blood-vessels of the brain were filled with gelatinous coagulable blood, which presented altered blood-corpuscles and acicular crystals." Dr. Halford, about two years since, figured and described in the 'Quarterly Journal of Microscopical Science,' the microscopic appearance of the blood of a dog killed by snake-bite. He particularly drew attention to the enormous increase in the number of white corpuscles in the blood. Dr. Joseph Jones concludes that the special toxic effect of the poison of the snake is due to its destructive effects on the red blood-corpuscle. Mr. Frank Buckland, in a recent note on this subject, in his highly interesting journal, 'Land and Water,' says that the snake's poison seems to "curdle" the blood. It may very well be questioned how far it is right to attribute this condition of the blood to the *direct* action of the snake's poison. Should we attribute the buffy coat of the blood of a fever-patient to the *direct* action of the fever-poison ? or the increase of white corpuscles after blood-letting to some specific poison in the lancet ?

New Books.

The Record of Zoological Literature of 1867.—This, the fourth volume of the 'Record,' is issued in three parts, in accordance with a suggestion of Dr. Albert Günther, the editor, so that naturalists can purchase what is most interesting to them without being encumbered by other matter. The Vertebrates form one part; the Insects, Myriopods, and Arachnids another; and the third contains the Mollusca, Crustacea, Rotifera, Annelida, Scolecida, Echinodermata, Cœlenterata, and Protozoa. Dr. Günther, Professor Newton, Mr. W. S. Dallas, Dr. von Martens, and Professor E. P. Wright are the Recorders, and have performed their task in the same satisfactory manner as heretofore. A grant of 100*l*. was given by the British Association at Dundee and at Norwich to assist in the yearly publication of the 'Record,' and it is hoped that all working naturalists and also the patrons of science will procure this work and make good use of it. It is well known that Mr. Van Voorst the publisher is continuing this work, not for profit, which *he* will probably never realize, though his successors may, but we congratulate him more heartily upon the laurels which he will reap as a lover and patron of Zoological Science, than we should do if we thought he was about to benefit materially by his work.

Bristol Naturalist's Society.—This excellent and flourishing Society publishes its proceedings from time to time, and at the end of the year they form a neat little volume, which we now have before us. Mr. Lant Carpenter has for some time edited the reports of the Society, but we regret to see he has now been obliged to retire on account of the occupation of his time. In glancing through the pages of the reports, we came upon a paper by Mr. Groom-Napier on the Dodo, in which it is stated that there is an original picture of that obese bird in the Ashmolean Museum. This is we believe an error. In the University Museum there is the celebrated head, and recently a skeleton has been set up by the talented curator of the anatomical collection—Mr. Charles Robertson—from bones lately obtained in the Mauritius. It is rather amusing to read of Mr. Groom-Napier and some of his fellow-naturalists maintaining that the Dodo cannot be rightly associated with the pigeons. A careful study of its osteology would or ought to bring them round to the opinion of the chief zoologists of the day.

The Anatomy and Physiology of Vertebrates, Vol. III.*—Professor Owen has now completed his great work, but it reaches us too late to do it justice in the present number.

The Royal Medals of the Royal Society.—One of these medals has this year been awarded to Alfred R. Wallace, the distinguished traveller and philosophical zoologist, who is not unknown to the readers of this Journal.† It was particularly in view of his researches on the distribution of animals which led him to frame the theory of the origin of species by modification and descent, placed before the world simultaneously with Mr. Darwin's, that Mr. Wallace has received this high but well-earned recognition of his merits. The other Royal Medal was given to Dr. Salmon, of Trinity College, Dublin.

* Longmans.

† See his papers on "Ice-marks in North Wales," "Creation by Law," and 'On the Migrations of the Polynesians," all published in vol. vi. of the Journal.

THE ROYAL MICROSCOPICAL SOCIETY.

We have received two circulars relative to a change which is about to be made in the mode of publishing the Transactions of the above Society. It appears that in future they are no longer to be published under the auspices of the Society in the well-known 'Quarterly Journal of Microscopical Science,' edited by Dr. Lankester and his son, but in a new monthly journal to be issued by Mr. Hardwicke and edited by Dr. Lawson. We shall be glad to see both these journals thrive. Of the continued success of the old journal we have no doubt, more especially as the wholesome competition about to be created will stimulate editors and publishers. Of the new one we can of course say nothing at present. Our object in referring to this circumstance is, however, not so much to direct the attention of microscopical observers to it, as to express the opinion that a Society which has been at the trouble and expense of obtaining a Royal Charter of incorporation, and which has changed its members into "Fellows," should publish its own transactions independently of any periodical, however respectable and useful it may be. Whilst the Society was content to pursue its labours unostentatiously, and when all the members were charged the moderate annual subscription of a guinea, the publication of its transactions in some periodical was justifiable, but after the changes which have been made (whether they were proper or not is a matter of taste), we think it hardly consistent that the transactions should serve as a shuttlecock for rival publishers. If our anticipations should not be fulfilled, and it should be found that the circle of microscopical readers is not sufficiently extended to support a second journal, then the members will have to be referred back to the old journal, or to some new literary *protégé* of the council, and any one desirous of binding the Proceedings continuously, and placing them for reference upon his shelves, must take with them whatever may appear in the journal in which they have been published. But there is even a more serious objection than this. Recent events elsewhere have shown that connections of this kind are not conducive to good feeling amongst the members of the council of a learned society, and we should indeed be sorry to see dissatisfaction arise in this one, which might necessitate a "Committee of Inquiry," accompanied as such proceedings usually are, by all the amenities of a scientific controversy. We have no desire to place any obstruction in the way of the council, but it is obviously our duty to mention these matters before the trouble has arisen. It appears to us that they have made more than one mistake. The charter of incorporation and change of names has in no wise elevated the Society, or its

members; but has entailed an expenditure which has not alone necessitated an increased subscription to new members (a double tariff in fact), but has so reduced the funds as to render it a matter of difficulty to pay the postage on the Transactions. The publication of those in the old journal a day longer than was necessary was another mistake; the transference to a rival, a third. The Council should charge all members alike, publish their own Transactions, and limit their moral responsibility to the record of what passes at their meetings. If these hints pass unheeded now, the time will come when they will be remembered.

Quarterly List of Publications received for Review.

1. On the Anatomy of Vertebrates. Vol. III. Mammals. By Richard Owen, F.R.S., &c. 614 *Woodcuts.* *Longmans & Co.*
2. A Practical Treatise on Metallurgy, adapted from the last German Edition of Professor Kerl's Metallurgy. By Wm. Crookes, F.R.S., and E. Röhrig, Ph.D. 207 *Woodcuts.* *Longmans & Co.*
3. Essays on Physiological Subjects. By Gilbert W. Child, M.D., F.L.S., &c. *Longmans & Co.*
4. Notes on the Metals. Being a Second Series of Chemical Notes for the Lecture Room. By Thomas Wood, Ph.D., F.C.S. *Longmans & Co.*
5. Fownes's Manual of Elementary Chemistry. Edited by Henry Bence Jones and Henry Watts. Tenth Edition. 193 *Engravings.* *Churchill & Sons.*
6. The Elements of Heat and of Non-Metallic Chemistry. 74 *Woodcuts.* By Frederick Guthrie, B.A. Lond., &c. *John Van Voorst.*
7. Appendix to the Manual of Mollusca of S. P. Woodward, A.L.S., containing such Recent and Fossil Shells as are not mentioned in the Second Edition of that Work. By Ralph Tate, A.L.S., F.G.S. *Virtue & Co.*
8. Travels in the East Indian Archipelago. By Albert S. Bickmore, M.A., F.R.G.S., &c. *Copiously Illustrated.* *John Murray.*
9. A Treatise on the Action of Vis Inertiæ in the Ocean. By W. L. Jordan, F.R.G.S. *Longmans & Co.*

PAMPHLETS AND PERIODICALS.

On the Regenerative Gas Furnace, as applied to the Manufacture of Cast Steel. By C. W. Siemens, F.R.S. *London: Harrison & Sons.*

On Puddling Iron. Same Author. *London: Newbery & Alexander.*

On Geological Time, and the Probable Date of the Glacial and Upper Miocene Period. By James Croll.

Notes on the Chemical Geology of the Gold Fields of California. By J. Arthur Phillips.

The Liverpool Medical and Surgical Reports.
London: Churchill. Liverpool: Holden.

New Pages of Natural History. Meteors and Meteorites. Caves and their Contents. Fossil Fish. By H. P. Malet. *T. C. Newby.*

Publications of the Smithsonian Institution, Washington:—

Observations on the Polyzoa. 9 *Plates.* By A. Hyatt.

Observations on the Metamorphosis of Siredon into Amblystoma. By O. C. Marsh, Yale College.

Results of Meteorological Observations made at Marietta, Ohio, between 1826 and 1859 inclusive. By S. P. Hildreth. Reduced and discussed by C. A. Schott.

Physical Observations on the Arctic Seas. By Isaac J. Hayes, M.D. Reduced and discussed by C. A. Schott.

Francis Peabody.

Smithsonian Report for 1866.

A Guide to the Study of Insects, and a Treatise on those Injurious and Beneficial to Crops. By A. S. Packard, jun., M.D.

On the Source of Light in Luminous Flames. Dr. Frankland, F.R.S.

The Rainfall in Devonshire during 1866–1867. By W. Pengelly, F.R.S., &c.

On the Condition of Some of the Bones found in Kent's Cavern, near Torquay, Devonshire. Same Author.

The Literature of Kent's Cavern, Torquay, prior to 1859. Same Author.

The History of the Discovery of Fossil Fish in the Devonian Rocks of Devon and Cornwall. Same Author.

The Submerged Forest and Pebble Ridge of Barnstaple Bay. Same Author.

Third Report of the Committee for Exploring Kent's Cavern. (W. Pengelly, Reporter.)

The Science of Man: a Bird's-eye View of the Wide and Fertile Field of Anthrology. By Charles Bray. *Longmans & Co.*

Twenty-second Annual Report of the Board of Trustees of the Public Schools of the City of Washington.

Notes on Books. Being an Analysis of the Works published during each Quarter by *Longmans & Co.*

The Geological Magazine.

The London Student.

The Popular Science Review.

The Westminster Review.

The American Naturalist, Salem, Massachusetts.

The Public Health.

PROCEEDINGS OF LEARNED SOCIETIES, &c.

Transactions and Proceedings of the Royal Society of Victoria.

Proceedings of the Bristol Naturalist's Society. Edited by W. L. Carpenter, B.A., B.Sc.

Journal of the Historical and Archæological Association of Ireland. *Dublin: McGlashan.*

Proceedings and Papers of the Kilkenny and South-East of Ireland Archæological Society. *Dublin: McGlashan.*

Journal of the Transactions of the Victoria Institute.

Transactions of the Clinical Society of London.*

Proceedings of the Liverpool Literary and Philosophical Society.

Proceedings of the Royal Institution of Great Britain.

" " Royal Society.

" " Royal Astronomical Society.

" " Royal Geographical Society.

" " Geological Society.

" " Zoological Society.

* Founded January 10, 1868. *President*, Sir Thomas Watson, Bart., F.R.S. *Honorary Secretaries*, Dr. Burdon Sanderson, F.R.S.; and G. W. Callender. Publishers of the Transactions, Spottiswoode & Co

JOURNAL OF SCIENCE.

APRIL, 1869.

I. THE MALAY ARCHIPELAGO.*

NOTHING affords greater relief to the hard-worked scientific littérateur, who is compelled day by day and week by week to pore over the labours and investigations of experimentalists, or to sift the theories of speculative philosophers, until his brain becomes confused with the long lists of new genera and species which are introduced into every province of nature's realm, or with the hypotheses, more or less plausible, propounded by each new thinker, than to cast aside such dry and often uninteresting technicalities, and to follow, though it be but in imagination, one of those free lances of science, the Naturalist Traveller. It is pleasant, indeed, to wander with him through distant regions of the globe, little known to Europeans

* 1. 'The Malay Archipelago: The Land of the Orang-Utan and the Bird of Paradise. A Narrative of Travel, with Studies of Man and Nature.' By Alfred Russel Wallace, author of 'Travels on the Amazon and Rio Negro,' &c. 2 vols. 8vo, with 51 Illustrations and 9 Maps. London: Macmillan & Co. 1869.

2. 'Travels in the East Indian Archipelago.' By Albert S. Bickmore, M.A., Professor of Natural History in Madison University, Hamilton, N. Y. 1 vol. 8vo, with 36 Illustrations and 2 Maps. London: John Murray. 1868.

even by name, to laugh with him at the mute astonishment of his savage acquaintances as he follows his scientific pursuits, or *at* him as he practises a little of that literary archery in which all travellers are supposed to excel.

The life of such a man in many senses resembles our own, but he experiences greater extremes of physical enjoyment and privation, of mental suffering and delight; and one of his chief advantages over us is the lasting pleasure which must remain when he returns to civilized life and subsides into the useful member of a family, the occupant of a cherished home. Then the remembrance of his exciting dangers abroad must afford him as much satisfaction as that of his most enjoyable hours. As he walks through the market, and his glance falls upon a tropical fruit, his mind must wander back to the virgin forest where he plucked it fresh and luscious from the tree; or as he inspects the treasures of some modest museum, and a rare creature, of which nothing but the skin is a reality, meets his eye, he starts for an instant, as he remembers with what surprise he first saw that form, here inanimate and perhaps disfigured by the dust of years, spring past him instinct with life as he wandered along the forest path, and disappear in the jungle before he had time even to raise his fowling-piece or rifle. Under the shade full of birds standing on the chimneypiece of some labourer's cottage, he espies in every little bright-winged creature a reminiscence of some new locality which he visited in times gone by; and whilst we should associate such objects with the auction mart, and estimate how many shillings the collection may have cost, he sees, perhaps, in one of the little feathered forms alone, the type of one which necessitated a whole day's pursuit and an unusual expenditure of his limited means. How thankful should we be to those enterprising and adventurous traders who bring into our parlours, boudoirs, and cottages the rarest and loveliest productions of tropical climes, and enable us to possess them for an outlay in some cases less than is requisite to obtain them where they are produced by nature.*

Nor must it be supposed that the roving naturalist passes through one continued series of privations all the year round, or lives in clover only when his gun supplies him with a superabundance of game; where he wanders, civilized men are often few and far between, and wherever the traveller appears, he brings to the colonist, what is more precious than gold or jewels, the sound of a cultivated voice, the recollection of home and friends far away; and no wonder that he is now and then a little petted and spoiled.

Mr. Wallace thus describes his life in Celebes: †—

* Mr. Wallace tells us (vol. i., p. 473) that "numbers of the handsome but very common cones, cowries, and olives" (shells) "sold in the streets of London for a penny each" are natives of Amboyna, "where they cannot be bought so cheaply."

† Wallace, vol. i., pp. 362–3.

"My host Mr. M. enjoyed a thoroughly country life, depending almost entirely on his gun and dogs to supply his table. Wild pigs of large size were very plentiful, and he generally got one or two a-week, besides deer occasionally, and abundance of jungle-fowl, hornbills, and great fruit pigeons. His buffaloes supplied plenty of milk, from which he made his own but er; he grew his own rice and coffee, and had ducks, fowls, and their eggs in profusion. His palm-trees supplied him all the year round with 'saguoir,' which takes the place of beer; and the sugar made from them is an excellent sweetmeat. All the fine tropical vegetables and fruits were abundant in their season, and his cigars were made from tobacco of his own raising. He kindly sent me a bamboo of buffalo-milk every morning; it was as thick as cream, and required diluting with water to keep it fluid during the day. It mixes very well with tea and coffee, although it has a slight peculiar flavour, which after a time is not disagreeable. I also got as much sweet 'sagueir' as I liked to drink, and Mr. M. always sent me a piece of each pig he killed, which with fowls, eggs, and the birds we shot ourselves, and buffalo beef about once a fortnight, kept my larder sufficiently well supplied."

So much for the creature comforts, and now as regards the intellectual enjoyment which they accompanied. Our readers will not be surprised to hear that under the circumstances the author's pursuits as a naturalist were equally pleasant.

"I have rarely enjoyed myself more than during my residence here. As I sat taking my coffee at six in the morning, rare birds would often be seen on some tree close by, when I would hastily sally out in my slippers, and perhaps secure a prize I had been seeking after for weeks. The great hornbills of Celebes (*Buceros cassidix*) would often come with loud-flapping wings, and perch upon a lofty tree just in front of me; and the black baboon monkeys (*Cynopithecus nigrescens*) often stared down in astonishment at such an intrusion into their domains; while at night, herds of wild pigs roamed about the house, devouring refuse, and obliging us to put away everything eatable or breakable from our little cooking-house. A few minutes' search on the fallen trees around my house at sunrise and sunset would often produce me more beetles than I would meet with in a day's collecting, and odd moments could be made valuable which when living in villages or at a distance from the forest are inevitably wasted. Where the sugar-palms were dripping with sap, flies congregated in immense numbers, and it was by spending half-an-hour at these when I had the time to spare that I obtained the finest and most remarkable collection of this group of insects that I have ever made.

"Then what delightful hours I passed wandering up and down the dry river-courses, full of water-holes and rocks and fallen trees, and overshadowed by magnificent vegetation! I soon got to know every hole and rock and stump, and came up to each with cautious step and bated breath to see what treasures it would produce."*

* Wallace, vol. i., pp. 364–5.

But the path of the naturalist traveller is not always so smooth: sometimes he is obliged to drag his weary body through marsh and morass, harassed by all kinds of tropical pests and encompassed by hidden dangers.

"When I reached Suban again," says Mr Bickmore,* "I felt a peculiar smarting and itching sensation at the ankles, and found my stockings red with blood. Turning them down I found both ankles perfectly fringed with blood-suckers, some of which had filled themselves until they seemed ready to burst. One had even crawled down to my foot and made an incision which allowed the blood to pour out through my canvas shoe. All this day we have suffered from these disgusting pests, our horses became quite striped with their own blood, and a dog that followed us looked as if he had run through a pool of clotted gore before we reached the highway again. Of all the pests I have experienced in the Tropics, or in any land, whether mosquitoes, blackflies, ants, snakes, or viler vermin, these are most annoying and disgusting."

And Mr. Wallace tells us † how, when the rains began at Celebes, "numbers of huge millipedes, as thick as one's finger and eight or ten inches long, crawled about everywhere, in the paths, on trees, about the houses;" and how he found, on rising one morning, that he had had one of them for a bedfellow!

In regard to trials and dangers, both travellers have their stories to narrate. Mr. Wallace tells his in modest and unaffected language and without any pretensions to heroism, whilst Mr. Bickmore uses such incidents for book-making purposes; and according to his own account, the Professor of Natural History at Madison University must have been as courageous as he was gallant, for whilst the terrible monsters of the animal kingdom fell beneath the blows of his axe, and his coolness was the admiration of the native men, we have the blushing confession that he was singled out by the dark beauties as the favoured object of their "osculatory salutes." But it is quite obvious to any one who has read the two works with care that the author who lays claim to the greatest coolness and courage, in reality experienced less opportunities for the exercise of either faculty: as to the osculatory business, we doubt not that the dark beauties *did* exhibit their good taste, and for the reason assigned by Mr. Bickmore, namely, as "they might never again have the privilege of kissing a gentleman with a white face." ‡ The contrast between the style of the two writers is best seen in the description given by each of them, of an adventure he had with a python. Mr. Wallace discovered his snake in the roof within a yard of his head.

"He was compactly coiled up in a kind of knot; and I could detect his head and his bright eyes in the very centre of the folds. The

* Bickmore, pp. 492–3. † Wallace, vol. i., p. 376.
‡ Bickmore, p. 193.

noise of the evening before was now explained. A python had climbed up one of the posts of the house, and had made his way under the thatch within a yard of my head, taking up a comfortable position in the roof—and I had slept soundly all night directly under him.

"I called to my two boys who were skinning birds below, and said, 'Here's a big snake in the roof;' but as soon as I had shown it to them they rushed out of the house and begged me to come out directly. Finding they were too much afraid to do anything, we called some of the labourers in the plantation, and soon had half-a-dozen men in consultation outside. One of these, a native of Bouru, where there are a great many snakes, said he would get him out, and proceeded to work in a business-like manner. He made a strong noose of rattan, and with a long pole in the other hand poked at the snake, which then began slowly to uncoil itself. He then managed to slip the noose over its head, and getting it well on to the body dragged the animal down. There was a great scuffle as the snake coiled round the chairs and posts to resist his enemy, but at length the man caught hold of its tail, rushed out of the house (running so quick that the creature seemed quite confounded), and tried to strike its head against a tree. He missed however, and let go, and the snake got close under a dead trunk. It was again poked out, and again the Bouru man caught hold of its tail, and running away quickly dashed its head with a swing against a tree, and it was then easily killed with a hatchet. It was about twelve feet long and very thick, capable of doing much mischief and of swallowing a dog or a child." *

Mr. Bickmore's python story is reserved as the crowning sensation, the *bonne-bouche*, of his work. This snake did not come upon him unawares; he had it presented to him in a cage, from which it escaped, and on searching for it, he found it coiled up in the ship's boat, on the deck of the vessel in which he was sailing. According to his account, all about him were cowards, he alone a hero; and the story of the death-struggle, though intended to be thrilling, is amusing in the extreme. It is illustrated by a plate, in which the hero is figured, apparently in his night costume (but that is explained), wielding an axe, and the fierce monster, with extended jaws, is about to dart upon him, whilst nine sailors and officers are looking on as unconcernedly as though they were witnessing a game of billiards. To add to the horror of the tale, "the first mate armed himself with a revolver," and every moment the hero expected to hear a report, and find himself shot by some of the braves behind him! "I felt the blood chill in my veins as for an instant we glanced at each other's eyes, and both instinctively realized that one of us two must die on the spot."†

Strange biological phenomenon! Here we have the sudden chilling of the sanguineous fluid of a warm-blooded animal, bring-

* Wallace, vol. i., p. 466. † Bickmore, p. 541.

ing him into sympathy with a cold-blooded reptile, and enabling the two for an instant to appreciate each other's instinctive sensations.

However, we must not harrow the feelings of our readers, and therefore conclude by stating that the hero was victorious, and not only survived to tell his own tale, but went on to China, "and passed through more continued dangers and yet greater hardships than in the East Indian Archipelago." We should be harsh critics if we concluded Mr. Bickmore's work in his own words, for it might leave an impression on the reader's mind that it has nothing to recommend it except his sensational adventures. For the sake of science, as well as his own, we would advise the author, if he publishes another work, to keep such matter distinct from the more sober details of his experience. The fact is, that he spent a year *very comfortably* in the Dutch settlements of the Archipelago, possessing ample means for the attainment of his object, which was to make a collection of shells. He carried letters of introduction from his Government to the leading authorities, and usually travelled with an armed escort. He appears to have been no sportsman, although there are one or two passages in his work which would lead his readers to think the contrary, and almost always secured his game with a silver bullet. The headings of his pages are often sensational, as—"Among the Cannibals;"* "Riding along the Edge of a Precipice;"† "Among Tigers;"‡ "We come upon an Elephant;"§ "The Head-hunters of Ceram;"‖ All these horrors (excepting the "precipice," which resembles one of those winding roads round a marine cliff which our readers have, no doubt, frequently met with nearer home than Java, and the "Head-hunters," of whom "the Resident kindly" sent to invite a few to dance before him, as we see Kaffirs dance at Wombwell's menagerie) were only heard of by the author,¶ and it would have been better to reserve them for a Christmas story for boys, as an eminent African traveller has recently done, and in which they would have shone to more advantage than in a scientific work, the value of which depends upon its trustworthiness.

But whilst we feel bound, in the interests of science, to censure Mr. Bickmore's sensational statements of facts, and in that of literature, to draw attention to his Yankee phraseology, as when he speaks of what he saw "back of the village," and tells us that children "help support their parents;" or that he stood "half querying;" in consequence of which imperfections his book is *not* "quite all a European palate could desire," we still tender to him our thanks

* Bickmore, p. 125. † P. 419. ‡ P. 515. § P. 513. ‖ P. 203.

¶ A "head-hunter," along with one of the beautiful palms, the "Penang, or Betel-nut Palm," which illustrate Mr. Bickmore's work, have been introduced by our artist into his vignette. Mr. Wallace, we may here observe, slept in a Dyak-hut in Borneo, "very comfortably with half-a-dozen smoke-dried human skulls suspended over his head."

for his valuable contribution to our hitherto imperfect knowledge of the Malay Archipelago, and to the publisher, for the admirable illustrations, many of them from photographs, with which the work is enriched.

His account of some of the natural productions of the Archipelago is interesting; indeed, so far as those are concerned whose intrinsic value in civilized life is the greatest, such as sugar, with its manufacturing processes,* nutmeg and mace,† camphor,‡ his information is full and valuable. His description of the various fruits and trees is also exceedingly interesting; and the reader is enabled to appreciate the beauty of the latter through the well-executed plates already referred to. A comparison of his account of the curious fruit of the Durian (*Durio Zibethinus*) § with that of Mr. Wallace || illustrates in an amusing manner the diversity of human tastes; and, as the fruit has scarcely ever been mentioned in England, it may be briefly noticed here. The "Durian" is a large spherical fruit, covered with sharply-pointed tubercles and a hard shell. Within, it is divided into several parts, and (according to Bickmore) it contains "a pale yellow substance of the consistency of thick cream, and having an odour of putrid animal matter, so strong that a single fruit is enough to infect the air of a whole house." The taste is described as similar to "fresh cream and filberts," but the odour was such as to repel the American traveller. Our own countryman describes the fruit in similar terms, and says "it smells like rotten onions;" but then bursting into a song in praise of its taste, which, he says, "resembles custard highly flavoured with almonds," but "intermingled with wafts of flavour that call to mind cream cheese, onion sauce, brown sherry, and other incongruities" (!) he tells us that he was a confirmed Durian eater, and, although Europeans cannot bear the fruit, and Mr. Wallace possessed his taste only in common with the savages amongst whom he lived so long, he considers it would be "worth a voyage to the East to experience the new sensation of eating it." Verily there is no accounting for tastes, and we should not be surprised if our author, or some one endowed with similar proclivities, were to tell us that he considers it worth while enduring all the hardships of a Russian winter to taste fresh caviare in Astrachan!

But Mr. Wallace has also some peculiar metaphysical theories concerning this strange fruit, for it furnishes him with evidence against the argument from design.

"The Durian is, however, sometimes dangerous. When the fruit begins to ripen it falls daily and almost hourly, and accidents not

* Bickmore, pp. 68 to 70. † Pp. 222-3. ‡ P. 433. § P. 91.
|| Wallace, vol. i., p. 118.

unfrequently happen to persons walking or working under the trees. When a Durian strikes a man in its fall it produces a dreadful wound, the strong spines tearing open the flesh, while the blow itself is very heavy; but from this very circumstance death rarely ensues, the copious effusion of blood preventing the inflammation which might otherwise take place. A Dyak chief informed me that he had been struck down by a Durian falling on his head, which he thought would certainly have caused his death, yet he recovered in a very short time.

"Poets and moralists, judging from our English trees and fruits, have thought that small fruits always grew on lofty trees, so that their fall should be harmless to man, while the large ones trailed on the ground. Two of the largest and heaviest fruits known, however, the Brazil-nut fruit (*Bertholletia*) and Durian, grow on lofty forest trees, from which they fall as soon as they are ripe, and often wound or kill the native inhabitants. From this we may learn two things: first, not to draw general conclusions from a very partial view of nature; and secondly, that trees and fruits, no less than the varied productions of the animal kingdom, do not appear to be organized with exclusive reference to the use and convenience of man." *

With the first sentence in the author's closing remarks, namely, that we should not draw general conclusions from a very partial view of nature, we heartily concur; and this is precisely the error into which he and similar argumentators fall; but we should like to know who has ever been so foolish as to state that "trees and fruits, no less than the varied productions of the animal kingdom, *are* organized with *exclusive* reference to the use and convenience of man." We certainly do not remember ever having seen such a doctrine propounded, either by poet or moralist; but if we found such a position assumed, we should certainly not adduce the author's illustration as evidence against its validity. As well might he say that because fowling-pieces sometimes kill sportsmen who are foolish enough to get into the way when they are going off, therefore fowling-pieces were not designed for the exclusive use of Man!

But, on the other hand, if we wish for a mass of evidence in favour of design, before which Paley pales, we need only read the author's account of the Bamboo and its uses, which follows immediately upon that of the Durian. He shows that it is indispensable to the natives. Looking at their mental condition, they could not have existed without it, or some similar boon of Providence. Page after page of the work is occupied with an account of its uses. Every fraction of it is utilized. It enters into the constitution of their dwellings, serves as the raw material from which they make hen-coops, cages, fish-traps, bridges, aqueducts, water-buckets,

* Wallace, vol. i., pp. 119–20.

cooking utensils, preserve jars, dagger-sheaths, pipes, cords, &c.; and yet he says:* "It is probable that my limited means of observation did not make me acquainted with one half the ways in which it is serviceable to the Dyaks of Sarawak."

But upon what principle is this wonderful adaptation of means to ends explicable? The author gives us no clue to the mystery, *his* philosophy being merely negative. Does pure Darwinism account for it? Is it the survival of the fittest by means of natural selection? That is to say, has nature selected the fittest plant for Man's use, and allowed it to survive? No, that is not Mr. Darwin's theory. According to his view, which is no doubt correct as far as it goes, those forms of life survive which are the best able to resist adverse conditions of existence; and therefore, although the presence of the Bamboo in Borneo may help us to understand why Man has survived there, superseding perhaps some Simian form of life, yet it throws no light upon the adaptability of the vegetable to the wants of an animal (Man) not yet formed, whilst it was struggling with the surrounding conditions of existence.

Shall we gain a clue to the mystery by calling in the aid of the Huxleyan doctrine of "Matter and Law?" Wiser brains than ours may be able to apply that misty-physical philosophy, as recently enunciated by its author in a contemporary;† but we are constrained to admit that we do not yet clearly comprehend it, and are therefore unable to apply it in the case under consideration. "Matter," no doubt, there is—that is quite clear; and "Law," no one can ignore; but our difficulty is to ascertain whether in the case under consideration it is matter that legislates, or the law that is material; and we confess we have given it up in despair, for, after all, the whole phenomenon may be but "the unknown and hypothetical cause of states of our own consciousness;" and then of course it would be best to follow Professor Huxley's "wise advice," and "not trouble ourselves about matters of which, however important they may be, we know nothing, and can know nothing."

Well, then, as Darwinism fails to explain the phenomenon, and Huxleyism declines to come to our aid, we must, at the risk of being ranked amongst the superstitious, appeal to a very old-fashioned doctrine to account for the wonderful adaptability of every part of this beautiful tropical plant to the necessities and luxuries of what would otherwise be helpless human beings; and perhaps we may be permitted to cling for a little while longer to the delusion that a beneficent Deity, to whom there is no past nor future, does exist,

* Wallace, p. 126.

† The 'Fortnightly,' edited by John Morley, No. xxvi., Feb., 1861, in which the curious will find the latest exposition of the Materialistic doctrine, by one of its ablest professors.

and that it is He who, in ages long past, provided thus bountifully for the wants of His children still uncreated! We hope, notwithstanding the author's remark which has led to these reflections, that we have his assent to our views and inference.

LET not our readers, however, for an instant suppose that because we have grouped the two works before us under one heading, we therefore consider them to possess equal merit or scientific value. It happens that they have appeared about the same time, and treat of the same region of which little is known in civilized Europe; but Mr. Bickmore, who is an American Professor of Natural History, spent only twelve months in the Malay Archipelago, confining his visits and observations to the Dutch possessions there, and occupied himself chiefly in purchasing valuable shells from the natives; whilst our own countrymen, to whose work we now propose to direct special attention, resided in the Archipelago about eight years, during which period he visited and studied the physical geography and natural history of all the most important islands, including Borneo, Sumatra, Java, Bali, Lombok, Celebes, the Moluccas, New Guinea, with the surrounding islands, and the Malay Peninsula. Indeed, Mr. Wallace's book, which has long been expected by naturalists, is likely to be the standard work on those regions. The author, as most people are aware, is, so to speak, the originator of that view which Mr. Darwin (to whom his book is dedicated) has developed into a well-defined theory—the theory of Natural Selection; and although, in his published works, Mr. Darwin has traversed a wider range of Physical Science, and deals with more extended areas of the earth's surface than the author, yet we believe that the present work will be found to exercise a more potent influence, in the promulgation of the advanced theory, than the well-known treatises which have been published from time to time by the able writer whose name it bears.

For Mr. Wallace himself observed the phenomena which suggested to his mind the theory of natural selection; and although he seldom refers to that theory, and then only as though he were a modest disciple of Mr. Darwin, he brings those phenomena vividly before his readers; and the previous works of the last-named author having borne down prejudices and removed obstructions, the readers of the present treatise will be better prepared to accept the

conclusions to which its numerous and well-recorded facts unquestionably point. The author's theory (one that has been floating in the public mind for some time) is that the continent of Asia at one period extended much farther eastward, and that of Australia farther west, than at present, until they almost joined, and that the two continents were probably separated by the Lombok Strait, which divides an island of that name supposed to have formed part of Australia from Bali, another existing island which is believed to have constituted, along with Java and Sumatra, a portion of the old Asiatic continent. This hypothesis is kept before the reader throughout the work, and is supported by all the data which can be furnished by physical geography, zoology, botany, and the heterogeneous nature of the inhabitants of the Archipelago. A shallow sea surrounds the *Indo*-Malayan region, as the author calls it, embracing the Malay peninsula, Sumatra, Borneo, Java, and Bali: another shallow sea encloses the Papuan region, whilst a deep one embraces the islands of Celebes, Lombok, Sumbawa, Flores, Timor, and the Moluccas—all of which together constitute the *Austro*-Malayan region. These conditions are well shown in the map which accompanies the work.

The fauna of Australia seems to have crept as far as Lombok; that of Asia to Bali; and in the passage from one island to the other, or rather by the contrast between the natural productions of the two islands, the author seems to have been led to adopt the theory which is so ably expounded in his work. When he first visited Lombok, the most westerly of the Austro-Malayan Islands, he says:—

"Birds were plentiful and very interesting, and I now saw for the first time many Australian forms that are quite absent from the islands westward. Small white cockatoos were abundant, and their loud screams, conspicuous white colour, and pretty yellow crests, rendered them a very important feature in the landscape. This is the most westerly point on the globe where any of the family are to be found. Some small honeysuckers of the genus *Ptilotis*, and the strange mound-maker (*Megapodius gouldii*), are also here first met with on the traveller's journey eastward."

Subsequently he shows in detail how the Flora and Fauna of the Timor group—namely, Lombok, Flores, and Timor—represent the transition from the Asiatic to the Australian types. Thus there are—

	In Lombok.	In Flores.	In Timor.*
Javan birds	33	23	11
Australian birds	4	5	10

these islands being all separated from each other by a deep sea; and as the same rule applies in a greater or lesser degree to mammals, insects, and plants, the natural inference is, that the

* Wallace, vol. i., p. 320.

islands must at some time have been connected together; and, although he does not believe that Timor was actually connected with Australia in recent geological epochs, he considers that they were in much closer proximity than at present.

The human inhabitants of the Polynesian Archipelago, the author thinks, did not penetrate so far east as Lombok, and he draws the line between the Malayan and Polynesian races through the Sapy strait between the islands of Sumbawa and Flores, and northward through the Moluccas. This line of demarcation is shown upon another of the numerous maps which accompany the work.

To treat the subject with anything like particularity in this place would, however, be impossible, and for a full exposition of the author's views and theories we must refer our readers to the work itself, where they will find page after page of evidence to support them.*

And now what shall we say of the book, as the production of a naturalist and traveller? We think few will disagree with us when we pronounce it to be one of the most attractive and, at the same time, the most learned work on foreign travel, "with studies of man and nature," that has appeared in our language. It surpasses in scientific interest Mr. Darwin's Naturalist's Voyage in the 'Beagle' (and that is saying a great deal), because its author has been a more industrious observer and collector, and has been able to render it more attractive by the employment of modern methods of illustration; for these latter carry us into the heart of the remote and little-known regions which he visited, and enable us to form a good idea of their varied inhabitants of all kinds.† His collection "comprised nearly 3000 birds' skins of about 1000 species, and at least 20,000 beetles and butterflies of about 7000 species, besides some quadrupeds and land shells." ‡

* The following is an extract from the 'Proceedings of the Royal Society,' No cvi., Nov., 1868:—"A Royal Medal has been awarded to Mr. Alfred Russell Wallace, in recognition of the value of his many contributions to theoretical and practical zoology, among which his discussion of the conditions which have determined the distribution of animals in the Malay Archipelago (in a paper on the zoological geography of that region, published in the 'Proceedings of the Linnean Society' for 1859) occupies a prominent place.

"The case may be briefly stated thus:—The strait separating the islands of Baly and Lombok is only 15 miles wide; nevertheless the animal inhabitants of the islands are widely different, the fauna of the western island being substantially Indian, that of the eastern as distinctly Australian.

"Mr. Wallace has described, in a far more definite and complete manner than any previous observer, the physical and biological characters of the two regions which come into contact in the Malay Archipelago; he has given an exceedingly ingenious and probable solution of the difficulties of the problem, while his method of discussing it may serve as a model to future workers in the same field."

† In the second vignette, our artist has copied a portion of one of Mr. Wallace's plates, exhibiting the mode in which the natives shoot the Great Bird of Paradise.

‡ Wallace: Preface.

Nothing seems to have escaped his observation. The peculiar ways of the Chinese trader of Singapore amused him exceedingly.

"The shopkeeper is very good-natured; he will show you everything he has, and does not seem to mind if you buy nothing. He bates a little, but not so much as the Klings, who almost always ask twice what they are willing to take. If you buy a few things of him, he will speak to you afterwards every time you pass his shop, asking you to walk in and sit down, or take a cup of tea, and you wonder how he can get a living where so many sell the same trifling articles." *

We have met with something like this spirit in small continental towns. Then come the habits of the animal next below man in anatomical structure which he captured—the Orang-Utan. For that creature, by the way, he showed less sympathy than might have been expected in a Darwinian, for he appears to us to have shot it somewhat wantonly. The Dyak music made a great impression upon him, but we cannot say that we admire his taste in that respect. The association of art with savage life struck him as being sometimes very remarkable. At Dorey, in New Guinea, he found the worst savages whom he anywhere met with, and after describing their habits, he says: "If these people are not savages, where shall we find any? Yet they have all a decided love for the fine arts, and spend their leisure time in executing works whose good taste and elegance would be admired in our Schools of Design!" † This is the first step towards human culture, and it carries our minds back involuntarily to those periods in human history when rude outlines of animals, now extinct, were carved on knife and axe handles; but there are in those wonderful eastern islands traces of a civilization far different from this. In Java there exist vast piles of ruined temples, covering miles of ground; and in one spot "traces of nearly 400 temples have been found," ‡ whilst "the ruins of forts, palaces, baths, aqueducts, and temples can be everywhere traced."

The numerous and beautiful tropical plants, with their luscious fruits and varied uses, and all the denizens of the animal kingdom, come under the author's notice, as we have already seen; especially interesting is the account of the exquisite birds of Paradise, to obtain which he sacrificed health, strength, and almost life itself. Nor are the grander phenomena of nature, such as earthquakes and volcanoes, overlooked in the naturalist's zeal. Of those he speaks without exaggeration, whilst he seeks at the same time to convey to the reader's mind the stupendous changes which the occult forces of nature have brought about upon the earth's surface; and to them he largely attributes the physical configuration of the land, and the

* Wallace, vol. i., p. 33. † Vol. ii., p. 325. ‡ Vol. i., p. 166.

past and present geographical relations of the various islands which he visited. Political and social economy, good and evil government are discussed; and although the author is not likely to find many disciples in his advocacy of monopoly abroad and protection at home, yet the facts noted by him even on these subjects are well worthy of the consideration of practical minds. The great charm of the work is its obvious truthfulness and simplicity, and if the author sometimes misses opportunities (of which travellers usually avail themselves with such eagerness) of appealing to the sense of wonder in his readers, he inspires, on the other hand, the most implicit confidence in all he says, and often affords us some consolation for having to read about, rather than participate in his adventures.

After describing some of the beautiful scenery of Mount Ophir, in the Malay Peninsula, he concludes his account of it by saying:—"The top is a small rocky platform covered with Rhododendrons and other shrubs. The afternoon was clear and the view fine in its way—ranges of hill and valley everywhere covered with interminable forest, with glistening rivers winding among them. In a distant view a forest country is very monotonous, and no mountain I have ever ascended in the tropics presents a panorama equal to that from Snowdon, while the views in Switzerland are immeasurably superior."* Some satisfaction, this, to the tourist at home, whose means or opportunities will not allow him to visit the tropics.

Again, let us recommend the romantic enthusiast who longs to visit the court of an Eastern Rajah, and catch a glimpse of the beauties who inhabit the Harem, to pause and ascertain the author's experience in that way. He had an interview with a "Rajah," the Queen and her daughters, and concerning the latter he says:—

"And here I might (if I followed the example of most travellers) launch out into a glowing description of the charms of these damsels, the elegant costumes they wore, and the gold and silver ornaments with which they were adorned. The jacket, or body of purple gauze, would figure well in such a description, allowing the heaving bosom to be seen beneath it, while 'sparkling eyes,' and 'jetty tresses,' and 'tiny feet,' might be thrown in profusely. But, alas! regard for truth will not permit me to expatiate too admiringly on such topics, determined as I am to give as far as I can a true picture of the people and places I visit. The princesses were, it is true, sufficiently good-looking, yet neither their persons nor their garments had that appearance of freshness and cleanliness without which no other charms can be contemplated with pleasure. Everything had a dingy and faded appearance, very disagreeable and unroyal to a European eye."†

And, finally, it will be pleasing to our countrymen to hear that if the gigantic vegetation of the tropics has so long formed the theme of the traveller's admiration, we have in our English scenery

* Wallace, vol., i. p. 50. † Pp. 343–4.

a feature largely wanting in the tropical world, which more than compensates for the absence of Palms, Tree Ferns, and gigantic Fig-trees, namely, the masses of flowers which adorn our landscapes. After describing such scenery as can only be met with where nature has been most lavish of her tropical gifts, Mr. Wallace says:*—

"The reader who is familiar with tropical nature only through the medium of books and botanical gardens, will picture to himself in such a spot many other natural beauties. He will think that I have unaccountably forgotten to mention the brilliant flowers, which, in gorgeous masses of crimson, gold, or azure, must spangle these verdant precipices, hang over the cascade, and adorn the margin of the mountain stream. But what is the reality? In vain did I gaze over these vast walls of verdure, among the pendant creepers and bushy shrubs, all around the cascade, on the river's bank, or in the deep caverns and gloomy fissures,—not one single spot of bright colour could be seen, not one single tree or bush or creeper bore a flower sufficiently conspicuous to form an object in the landscape."

This peculiarity he explains by stating that it is the custom of travellers to have their attention drawn to the few rare and magnificent flowers which are here and there met with in hot climates, and are gathered together and fostered with so much care in our conservatories at home; but he adds, "During twelve years spent amid the grandest tropical vegetation, I have seen nothing comparable to the effect produced in our landscapes by gorse, broom, heather, wild hyacinths, hawthorn, purple orchises, and buttercups."†

And now, in conclusion, let us express the hope that in thus seeking to treat Mr. Wallace's work with impartiality, and to show how unprejudiced he usually is in his judgments, we may not have detracted from his merits as a literary man, nor yet from his work as an interesting record of a traveller's experiences. We might have selected far more "telling" passages for extracts than we have done, and perhaps thus have enabled the publishers to sell a few more copies of the work at the outset. But that is quite unnecessary. It will bear its own recommendation in its pages, and we have felt it our duty to place upon it, as far as we are able, the stamp of scientific authority, where there are so many scientific novels running their ephemeral course, so that every intelligent man who thinks fit to give it a permanent place upon his shelves may feel assured that he is depositing there for the benefit of posterity a highly valuable contribution to the scientific literature of our age.

* Pp. 371–2. † Wallace, vol. i., pp. 373.

II. THE PROJECTED MERSEY TUNNEL AND RAILWAY.

(From Liverpool to Birkenhead.)

By Sir CHARLES FOX.

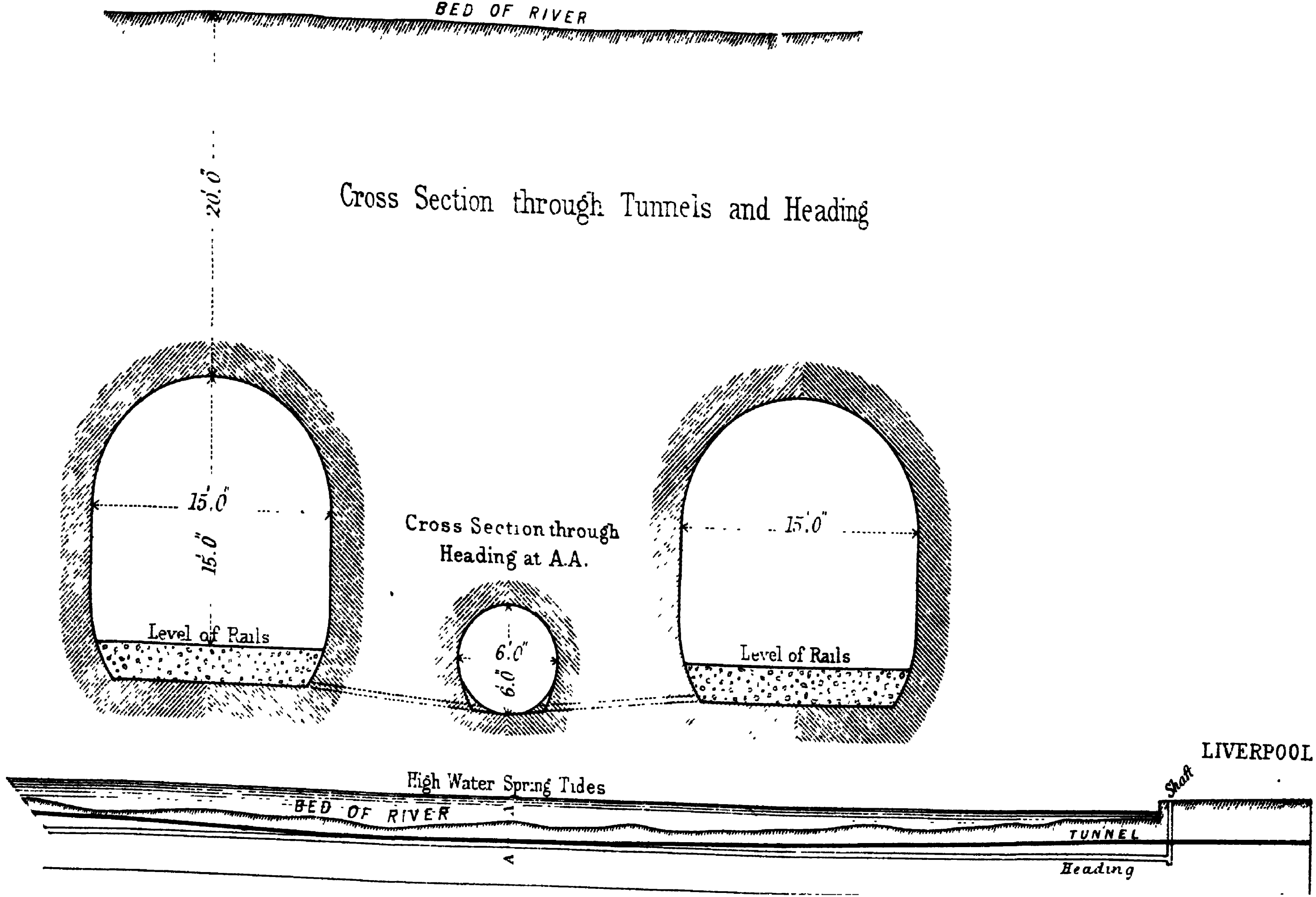
As a means of intercommunication between Liverpool and Birkenhead, a tunnel beneath the Mersey has been under consideration by leading men on both sides of the river for upwards of thirty-eight years; and when the inconvenience and loss both of time and money which the want of such a means of transit has ever occasioned are considered, it is, in these days of increased facilities, a matter of surprise that, while works of real difficulty have been carried to completion on every side, this obvious want should not have been satisfied.

There is but one opinion as to the importance of intercommunication between Liverpool and Birkenhead, and it being admitted that the great obstacle in the way of its realization is the doubt existing in the public mind as to the cost at which it can be attained, it has been felt that this doubt can never be overcome unless the nature of the river-bed is conclusively proved.

When this has been done, I am sure that the construction of a tunnel through the red sandstone rock under the Mersey will be found an easy and inexpensive operation, as, judging from the many similar works which have been executed in this rock during the last forty years (those most analogous having been tunnels of various dimensions carried on at considerable depth below the level of the bottom of the river, with a view of obtaining a more copious supply of water for the town of Liverpool), it has been ascertained that in no material can such works be effected at so small a cost as through the very strata now well known to exist in this locality, the amorphous nature of the rock rendering it peculiarly advantageous for tunnelling operations.

Tunnels have been made at a low price through chalk, as that material is readily excavated; but from its general looseness and its consequent tendency to fall, it is deemed necessary, for the purpose of ensuring safety, to put in brick or stone lining, and this, as compared with red sandstone, which generally requires no such lining, considerably augments the cost; and it must not be forgotten that the sandstone, when excavated from a tunnel in or near a town, is saleable for use as building material; while chalk, taken from a tunnel, being of no value, is more generally run to spoil.

It would appear that one of the most formidable hindrances in the way of getting capitalists to embark their money in making tunnels under rivers, of which very many are urgently needed,



BED OF RIVER
20.0"
Cross Section through Tunnels and Heading
15.0"
15.0"
Level of Rails
Cross Section through
Heading at A.A.
6.0"
6.0"
15.0"
Level of Rails
LIVERPOOL
Shaft
High Water Spring Tides
BED OF RIVER
TUNNEL
Heading

arises from the disposition which undoubtedly exists to form an unfair comparison between such works and the Thames Tunnel, which, as every one conversant with the circumstances connected with it will know, cost a very large sum, although passing under a river of no considerable breadth. This, however, is no fair criterion upon which to judge of any other case. This tunnel was constructed some forty years since, when the science of tunnel-making was but little understood, and when it had to be applied upon a very limited scale, without the advantages arising from many later improvements, and without the extensive experience derived during the last forty years from works of this nature, required in the development of the railway system all over the world.

This makes a comparison deceptive, to say nothing of the Thames Tunnel having to be constructed under all the difficulties of passing, not through London clay, which it would have done had it been placed a few feet deeper, but through the treacherous and loose silt and gravel of the bed of the river Thames, while the tunnel which forms the subject of this paper will pass through solid rock.

To attempt to draw a comparison between this project and the Thames Tunnel is but to show an entire want of acquaintance with the relative circumstances of the two cases, for it must be borne in mind that the Act authorizing the construction of the latter received the Royal Assent on June 24th, 1824, more than forty-four years since, and that the tunnel was not opened for passenger traffic till March 25th, 1843, having occupied a period of eighteen years and three-quarters in arriving at completion.

Were this work now taken in hand by an Engineer possessing the experience obtained in constructing tunnels since the period above referred to, taking care to place his work deep enough to let it pierce only the London clay (to have done which the present tunnel ought to be fifteen feet deeper than it is), no doubt the entire work could be completed for little more than a tithe of the cost (which was 454,700*l.*), and need not certainly occupy a longer period than two years, as is proved by the following facts:—

The excavation for the Thames Tunnel commenced in December, 1825, and all went on satisfactorily until 12th May, 1827, when, the upper portion of the works protruding above the London clay into the gravel and silt of the bed of the river, the first irruption of water took place, there being then a length of 545 feet of the tunnel constructed, which had been done in a period of seventeen months; so that, had no casualty occurred, and assuming that the rate of progress was not, as it no doubt would have been, augmented by the natural increase which always follows a better knowledge of any work, the whole 1200 feet would have been completed within

three years and two months; and this, be it remembered, would have been the result if made wholly from one end; whereas, with the present increased facilities and knowledge of the operation, it would have been carried on from both sides simultaneously, when, even at the then slow rate of progress, the time would be reduced to one year and seven months; so that there can be no doubt that, with present appliances, the work of the tunnel could, with perfect ease, be completed in one year and a quarter; and taking for the shafts and other matters, say, half a year more, the whole could with convenience be accomplished in one year and three-quarters.

In order to clear up every doubt, I propose, at an estimated cost of 20,000*l.*, to drive a heading under the Mersey from shore to shore, a distance of 1300 yards, and thus not only to prove the practicable nature of the larger and more complete undertaking, but also the future cost, whilst at the same time providing the necessary drainage and ventilation for the permanent works.

The first operation will be to sink a shaft on either side of the river, on land belonging to the Mersey Docks Board, to a depth of about 120 feet below the surface (see Plate, lower figure). The shaft on the Liverpool side will, for a depth of say 40 feet, pass through made ground, and will then enter, and for the remainder of its length be entirely through, the solid rock. That on the Birkenhead side will be in solid rock throughout. These shafts will be about 10 feet in diameter, and will terminate in large sumps for pumping purposes. At each will be erected permanent pumping engines and pumps of sufficient power to deal with the largest quantity of water that is likely to be met with, and which pumps will not only be used during the construction of the works, but be adapted for keeping the main tunnels permanently free from water. Winding engines will also be erected of sufficient power, not only to deal with the material excavated from the heading, but also with that from the tunnel itself.

The shafts having been sunk to the full depth, and the machinery fixed, the heading will be commenced from either end, and driven much in the same way as an ordinary mining water-level. It will have a very slight rise towards the middle of the river, so as to drain both ways into the shafts. Judging from experience, I expect that, at least, 4 yards lineal a day will be driven at either end, giving a total of 160 working days, or thereabouts, for the completion of the heading after the shafts are sunk. I have taken much pains to collect evidence as to the nature of the rock through which the heading will pass, and have found everyone conversant with the subject unanimous upon the point. The general result of my inquiries and observations cannot be more forcibly explained than by the following summary of evidence given before the Referees of the House of Commons in 1865.

The late Mr. Thomas Duncan, then Engineer to the Liverpool Waterworks, stated that he knew well the nature of the rock, which is not very porous. He did not think the quantity of water produced from the rock at Birkenhead and Liverpool would make the tunnel a difficult work of construction, and he did not believe there would be any difficulty in carrying it through so far as water is concerned. He considered that the "faults" existing in the sandstone rock, and shown on the geological map, were advantageous, as he had cut through many of them (having excavated in the red sandstone at various points over sixty square miles) and had nearly always found them filled up with a species of concrete, which was perfectly water-tight. In a few instances, however, he had found them filled with laminated rock, having a saccharine appearance, and evidently having been subjected to a great heat, and yet water-tight.

Mr. James Abernethy, C.E., stated that, having been Engineer to the Birkenhead Docks, he had large experience of the sandstone rock, and that the rock under the river is good hard red sandstone rock, of the same character as the rock excavated from the Birkenhead Docks, which is a close, compact, strong stone, suitable for building purposes.

Mr. John Fowler, C.E., stated that in framing his estimates he had well considered the question of possible faults in the rock, and, on the whole, preferred to have faults of the character known to exist in the red sandstone at Liverpool and Birkenhead, as they, being impervious to water, back up and limit in area the water contained in the interstices of the rock. The faults are filled either with clay or with some vitreous material. Mr. Fowler further stated that he considered red sandstone at all times the best material to construct tunnels through.

Besides the above testimony, there is the further fact that Mr. John Hawkshaw, C.E., F.R.S., proposes to construct a tunnel under the Mersey, near its mouth, where the river is very wide and the character of the rock less certain; and it is therefore evident that Engineers of eminence are agreed in considering the work of making a tunnel thoroughly practicable, and that at a moderate cost.

As much doubt has been expressed as to the possibility of driving the heading for any such sum as 20,000*l.*, I would remark that the Trustees have before them a tender from a responsible contractor, who is prepared to undertake to complete the work considerably within that amount, finding all necessary plant and machinery, and giving approved security to the extent of 5000*l.*

Again, the chief item in the cost of this work is that of excavation, and the Engineers already mentioned, and who gave evidence before the Referees, were agreed in considering 9*s.* a cubic yard an ample price for this work in the tunnel, including all possible contingencies, being, in fact, three times the cost of similar work under

ordinary circumstances. I have, however, taken 20*s.* per cubic yard for the excavation in the heading, which I believe to be far more than it can cost.

That a tunnel, or as it is called, a subway, can in the estimation of those competent to form an opinion, be carried under the river Thames at a very small cost, is, I think, proved by the fact that Parliament, last session, passed an Act for the "Tower Subway," proposed by Mr. P. W. Barlow, F.R.S., C.E., son of the highly-talented Professor of mechanics of that name, the capital for which is but 12,000*l.*, with power to borrow 4000*l.*

This work is now in course of construction, and is to consist of an excavation through the London clay 440 yards in length, lined with cast-iron cylinders $\frac{7}{8}$″ thick, with strengthened flanges, whose external diameter will be 7′ 1$\frac{3}{4}$″, or 7 feet inside.

At each end there will be a vertical shaft between 50 and 60 feet deep, fitted with lifts for the purpose of raising or lowering passengers from and to a saloon carriage, which will at very frequent intervals pass through the heading for the conveyance of passengers.

From each end the subway will fall towards the centre of the river at an inclination of about 1 in 40 to a level under the river, where the rails will be at a depth of 61′ 6″ below Trinity high-water mark.

With regard to the above, it may no doubt be said that it is as yet only a matter of estimate; and though given by an Engineer of standing and approved by Parliamentary committees—one of whose special duties it is to investigate the estimates for the purpose of testifying to their sufficiency,—yet the estimate might prove fallacious. I now, therefore, proceed to give the cost of an important work at Chicago, completed some time since, and in many respects analogous to the one of which I am treating, but beset with some difficulty not to be encountered in passing under the Mersey, arising in great measure from the more uncertain material through which the heading had to be driven; that at Chicago being clay, and that at Liverpool red sandstone—the one being driven for two miles, or 3520 yards, under Lake Michigan, the other only 1300 yards under the river Mersey.

The Chicago tunnel was made by Mr. Chesbrough, C.E., Engineer to the municipality of Chicago, for the purpose of obtaining a more ample supply of pure water for the inhabitants of that important city from a point beyond the reach of sewage contamination; hence its great length.

This work, embracing as it does two miles of heading carried through clay, lined with two rings of brickwork, including a sum of $120,000 expended on the two shafts and the appliances connected therewith, cost $380,000, or 76,000*l.*

The above amount spread over the 3520 lineal yards of heading gives 21*l.* 11*s.* as the cost of each lineal yard, and deducting therefrom 7*l.*, the value of the additional excavation, centering, and brick-lining (not found necessary in tunnels in the red sandstone), it will bring the price per lineal yard to 14*l.* 11*s.*, without taking into account the more than double value of labour at Chicago, which has unfortunately greatly augmented the outlay upon this work.

Now 20,000*l.* expended upon 1300 lineal yards of heading under the Mersey gives the price for each 15*l.* 5*s.*, so that, in drawing a comparison between the two works, a greater sum has been taken in the estimate for the one than has been actually expended on the other, and this is assuming the price of labour to be the same in both instances, which, however, is by no means the case, that at Chicago being very high.

I may here allude to a very interesting and instructive work, also very analogous to that proposed under the Mersey, which has been carried to a satisfactory conclusion at Attock, on the Khyrabad Pass, in India.

It consists of a heading 600 yards long, 6 feet square, driven under the river Indus through a rock, which forms its bed, at a depth of somewhat over 90 feet below the surface of the flood-water.

It has been carried on by a few labourers, under the charge of Mr. Robinson, who have succeeded in filling up the fissures they met with during the operation by simple "feather" wedging of wood, and have by this expedient been able to keep back all the water which otherwise would have flowed into the heading with a force due to the whole superincumbent column.

The cost of this work has been about 13,000*l.*, and spreading the whole outlay over the 600 yards, brings out the cost to about 21*l.* 14*s.* per yard, which goes to prove that, had the labour expended upon it been paid for only at English prices, it would have been executed at a considerably smaller cost than that arrived at by estimate for making the heading under the Mersey.

I have lately constructed a water-level, nearly one-third of a mile long, through harder rock, yet far less compact and more broken up, having much larger feeders of water than any to be expected in the red sandstone. In driving this heading and the shafts connected therewith, single feeders were met with yielding 1,000,000 gallons per diem, yet these were dealt with without serious difficulty or expense, the cost not having been one-half that estimated for the Mersey work.

In driving the heading a boring-rod would, as is usual in water-bearing strata, be kept ahead of, and at the top of, the work, and thus due notice would at once be given of any unusual feeder of water, should such exist.

All ordinary cracks in the sandstone are readily made water-tight by the use of a "feather" wedge of timber tightly driven into them. If a large crack were met with, containing water (a most unlikely thing, as has been already shown), a lining of iron would be put into the heading and pushed forward, as the excavation proceeded, until the fault was passed.

The heading will be circular, and 6 feet in diameter.* It will, when completed, be available not only for draining the tunnels, but for telegraphic purposes, and probably also for conveying water from the Welsh lakes to Liverpool, thus avoiding a lengthened détour and most expensive works.

The heading having been successfully driven, I am confident that there will be no difficulty in letting a contract for a double line of railway under the river Mersey for 100,000*l.*, which would, indeed, give a price of 77*l.* per lineal yard of tunnel—the work being through good hard sandstone and thoroughly drained by means of the heading; whereas 60*l.* a lineal yard is a large price for tunnels, even through clay, where, of course, heavy lining, including an invert, is required.

The river tunnel being completed, the remaining works necessary to bring the two towns of Liverpool and Birkenhead into complete communication with each other will be of a very ordinary kind, and free from any unusual contingency.

Under the existing Parliamentary powers, the railway can be completed in a direct line from Church Street, Liverpool, to Woodside, Birkenhead, with an intermediate station at the bottom of James Street, and by its means, and by trains running every few minutes, passengers will be conveyed between the termini in six minutes. The authorized line runs entirely either under the river or under streets, and not a single house will be taken for the railway itself, and only one or two for station purposes. The railway can be readily constructed without interference with the traffic of the streets. The main line will be double, with extensive sidings for goods, in direct communication with the dock lines on either side of the river.

Surveys have been completed of extensions, whereby the Mersey Railway can be made to form a direct connecting link between the important railway systems on either side of the river, and this at a moderate expense, and with the destruction of hardly any property.

The effect produced by the opening of this railway will be very great. The docks of Liverpool and Birkenhead, now under the same management, form the noblest emporium of trade in the world, but their joint usefulness is much impaired by the want of

* See Plate. It is unnecessary to give any detailed description of the Plate, as it explains itself.

satisfactory communication between the two sides of the river; and the immense resources of Birkenhead, developed at a cost of nearly 7,000,000*l.* sterling for docks alone, are lying comparatively idle, whilst the quays and docks on the Liverpool side are flooded with a trade increasing daily, and already over-tasking their capabilities.

More dock and quay accommodation must be found. On the Liverpool side, to construct fresh docks either north or south, is to place them miles away from the centre of trade—at the north, in a very exposed situation, almost unapproachable in heavy weather, at the south, only available for vessels of comparatively small draught—what then so natural as to utilize the expenditure at Birkenhead, now yielding but a nominal return, but which, with the Mersey Railway completed, would be placed in a very different position. The Birkenhead docks and warehouses would then, as regards both passengers and goods, be placed within a few minutes, in all weathers, of the heart of Liverpool.

The immense traffic to be expected under such altered circumstances, may be inferred from the fact that, with the present imperfect means of communication, often brought almost to a standstill by a fog, or a gale of wind, twenty millions of passengers, at least, pass over the ferries annually.

The Cheshire side of the Mersey abounds with pleasing sites for residential purposes, and not only New Brighton, but many other places, would experience an immediate increase if railway communication were established. Thousands of persons who would prefer a residence on that side, are, at present, deterred by the difficulties of the daily crossing to their places of business.

The construction of this railway, and its extensions would, also, place Liverpool in direct communication with North Wales and Holyhead.

Liverpool, Birkenhead, and their surroundings now contain at least seven hundred thousand inhabitants, and the steady increase of population renders means of communication every day more urgent.

If this railway be not soon completed, an immense expenditure must be incurred to improve the approaches to the landing stages, which will, after all, not get rid of the most serious inconveniences connected with the ferries, which are chiefly caused by fogs and storms.

Those who have interested themselves in the Mersey Railway are in earnest in the matter, and if they meet with but moderate assistance from those locally concerned, Liverpool and Birkenhead will soon be connected by a direct railway.

III. VESUVIUS.

WHAT Baden-Baden is among inland watering-places, Brighton and Scarborough among marine resorts, Epsom among race-courses, such is Vesuvius among volcanoes. The Spaniard ardently exclaims, "*Que no ha vista Sevilla, no ha vista maravilla;*"* and truly this may be said of Vesuvius. It is, *par excellence*, the type of volcanoes, both for its historical interest, and the natural beauty of its surroundings.

That it should be so will seem quite natural when we reflect, that from its position, near the centre of the earliest and highest civilization of Europe, its spasmodic movements were anxiously watched, and more or less frequently recorded for nearly eighteen hundred years; sixty-six eruptions having been chronicled between A.D. 79 and 1868.

With the exception of its sister volcano Etna, there is no other burning mountain whose history can compare for a moment in interest or extent with that of Vesuvius; indeed only a very few out of the 225 recognized active volcanoes were known five hundred years ago.

Among the many scientific visitors who were attracted last year to "the City of the Siren" by the activity of Vesuvius was the veteran Professor Phillips, who for more than fifteen years has filled the Chair of Geology in the University of Oxford.

Accompanied by an early geological friend and most excellent antiquary, Mr. John Edward Lee, of Caerleon, Professor Phillips examined Vesuvius, and the result lies before us in the shape of a small and neat octavo volume,† illustrated by two maps, nine plates, and thirty-five diagram woodcuts, expressive, but rough, like the scoriæ. tuffs, and lavas they so well depict.

Another tourist to Vesuvius, Mr. J. Logan Lobley, F.G.S., has also put on record an account of his own observations in an unpretending little volume‡ of fifty-five pages, accompanied by a view, a map, and a section of the mountain.

Isolated as we happily are in Britain from lands in which the subterranean energies of our earth still manifest themselves at the surface in the form of volcanic outbursts, it must not be supposed that our countrymen, who have for so long a time been foremost in all the other branches of cosmical science, should on this account have devoted but little attention to Plutonic investigations.

* "Who has not seen Seville has not seen a marvel."—*Spanish adage*.

† 'Vesuvius,' by John Phillips, M.A., D.C.L., LL.D., F.R.S., &c., &c. Oxford: Clarendon Press. 8vo. 1869. Pp. 355.

‡ 'Mount Vesuvius: a Descriptive, Historical, and Geological Account of the Volcano, with a Notice of the Recent Eruption,' &c. By J. Logan Lobley, F.G.S. 8vo. 1868. London: E. Stanford.

On the contrary, we recall the writings of Sir W. Hamilton,* Professor Babbage,† Mr. G. Poulett Scrope,‡ Dr. Daubeny,§ Principal Forbes,‖ Sir Charles Lyell,¶ Charles Darwin,** and many others who have each contributed a share to the world's store of knowledge on volcanic phenomena, and largely to the history of Vesuvius itself.

Any book therefore which may now be written upon Vesuvius, must of necessity draw largely upon these already written histories, and its author must be likewise indebted to Padre Della Torre, Guiscardi, Monticelli, Palmieri, and other foreigners who have given special attention to this volcanic mountain.

Nor can any description of Vesuvius be complete which does not include the account given by Pliny the younger of the eruption of A.D. 79, in which the elder Pliny lost his life.†† This eruption justly deserves the attention it has received of all subsequent historians, not only from the loss of the celebrated naturalist Pliny, but also because of the sudden overwhelming of those large and populous cities, Herculaneum, Pompeii, and Stabiæ, which at that time stood in the Campania on the shores of the Bay of Naples, and the exploration of whose buried streets and palaces has added so largely to our knowledge of the arts and civilization of the ancient Romans.

"Through eighteen centuries," writes Professor Phillips, "the dwellers round the Bay of Naples have watched with mingled pride, wonder, and alarm, the great solitary mountain whose shadow in the morning stretched across the sea, and whose evening splendour threw into far distance the snowy peaks of the Apennines.

"Well might they be proud of so fair a prospect. All around the mountain, and even climbing to half its height, stretch vineyards and orange-groves, populous towns and prosperous villages, churches, palaces, and ports; the well-paved road, and the Strada Ferrata. Here the Norman built his fortress, the Roman reared his amphitheatre; and long before the birth of Rome, the wandering Greek or Phœnician trader laid the foundations of Cumæ and Pæstrum, perhaps as long after an earlier race had built the giant walls of Arpinum and Alatrium, Ferentinum and Venafrum. Such has ever been this fertile land since history began to shed

* *Campi Phlegræi.* Fol. Naples, 1776.
† 'Geog. Proc.,' vol. ii. p. 72; and 9th 'Bridgewater Treatise,' p. 200.
‡ Scrope, 'On Volcanoes,' 2nd edition, 1862.
§ Daubeny, 'On Volcanoes,' 2nd edit., 1848; and QUART. JOURN. OF SCIENCE, vol. iii., p. 199.
‖ Forbes, in Brewster's 'Edinburgh Journ.,' 1829, &c., vol. iv., p. 12; and 'Miscellanies,' vol. i., part 2.
¶ Lyell's 'Principles.' 10th edit., vol. i., pp. 598–654.
** Darwin, 'On Volcanic Islands,' &c.
†† *Plinius Cæcilius Secundus* (*Caius*) *to Cornelius Tacitus.* Book vi., Epistle xvi. and Epistle xx.

light on ancient Hesperia; a country on which the sun shines in his strength, washed by a translucent sea, bordered by the most picturesque shores in the world, and these crowned by villas and palaces, temples and tombs, of every age and many nations—worshippers of Neptune the earth-shaker, and believers in Januarius, whose very image stays the heaving of the ground and arrests the current of lava. Well might they wonder and be terrified! More than fifty times since the Christian era has the mountain poured forth floods of lava and tossed up clouds of ashes; while far more frequent tremblings of the earth have justified the fable of antiquity, that Titanic forces lay oppressed but struggling below the heavy load of the Phlegræan hills."

"Threatened people live long," and the inhabitants of *Campania felix*, who, amidst perpetual fertility, have to put up with occasional terrors and sometimes to witness the destruction of their homes and churches by the devouring lava-streams, cannot be induced to quit the dangerous but lovely spot.

Thus we find the modern and flourishing town of Resina standing on the ashes and lavas beneath which Herculaneum lies buried: and Torre del Greco even nearer to the mountain than Resina, and three or four times, more or less, destroyed by lava-streams, its total destruction being all but accomplished (but for St. Januarius) by the eruption of 1861.

It has been already mentioned that sixty-six eruptions are on record since A.D. 79. These, as matter of course, have not only altered the appearence of the surrounding country, but have frequently changed the form and height of the crater itself.

Seen from the sea or from the Campagna, Vesuvius rises alone from a broad base, and its outlines sweep upwards in an easy curve, growing continually bolder towards the summit, and these, in ordinary periods of tranquillity, passing over an uneven but variable "dome" or "cone" 4000 feet high, to slopes on the opposite face not tamely identical, but harmoniously diverse. The view from Naples eastwards is in happy contrast with the opposite one, the northern outline being broken by a deep hollow, which is itself overlooked by a sharp angular crest 3760 feet above the sea. Thus the mountain appears double: the northern crest is now called the "Monte Somma," the hollow is the "Atrio del Cavallo," and the dome-shaped summit, now the highest part of all the area, is the modern "Monte Vesuvio."

Viewed from the south-west in the direction of Sorrento or Capri, Vesuvius is in front, and its long continuous slope comes down to Pompeii on the south, and to the sea at Torre del Greco, and Resina on the west; while on the north it is encircled by the rugged crests of Somma.

The histories of Somma and Vesuvius, as known to us, are

strikingly different. Somma, the broken external crest of the greater and earlier volcanic crater, has been unmoved in place, unchanged in form and height (save by atmospheric denudations) through eighteen centuries.

Vesuvius, born of Somma, and seated within the encircling grasp of its parent, is a variable heap, thrown up from time to time, and again, not seldom, by a greater effort of the same force, tossed away into the air, and scattered in clouds of dust over far away countries.

Thus it has happened often, in the course of these variations of energy that Vesuvius has risen to a conical height exceeding that of Somma by 500 or 600 feet, and again the top has been truncated to a level as low as Somma, or even as much below that mountain as we now behold it above it.*

Within the last four hundred years the cone of Vesuvius has been five several times gutted by explosive eruptions of a paroxysmal character, *viz.* in 1794, 1822, 1831, 1839, and 1850; and its central craters formed in this manner as often gradually refilled with matter, to be again in due time blown into the air.

B.C. 72 Vesuvius was unborn; and the great crater of Somma, a mile in diameter, its summit encompassed on all sides—save one which had a narrow breach—with broken and slippery precipices covered with wild vines, reared its truncated cone in silent grandeur unbroken by the least fretful token of an eruption.

To this wild spot retreated Spartacus and his small army at the beginning of the Servile War, the floor of the crater being then a nearly level surface, but deeply sunk below the encircling walls.

It was, no doubt, the great eruption of A.D. 79 which blew away nearly three quarters of the crater-walls of Somma, beneath whose ponderous ruins the towns of Herculaneum, Pompeii, and Stabiæ lie buried; and to this day we trace in the platform of the Pedimentina the outline of the base of the south-western portion of the ancient Somma, although, of course, much obscured by modern lava-flows.

Meantime, what remains of the old external crater is itself becoming choked up by the accumulation of all the lava-streams and fragmentary matter that are expelled towards the northern and outer side of the cone, which is also growing in bulk all round. It would therefore be in exact accordance with the habit of this volcano (as of volcanic mountains in general), if at length the valley of the "Atrio," which at present separates the remains of the ancient and far larger cone of Somma from the modern cone of Vesuvius, should be completely filled up, the two cones combined into one, of increased height and bulk, and ultimately, perhaps,

* Phillips, p. 174.

the entire conjoint mountain should be blown up by a more than ordinarily violent paroxysm, and the crater of Somma re-formed.*

Although many of the early writers have preserved for us much of interest which relates to Vesuvius, yet their ideas of telluric phenomena were always so involved with the supernatural, that we are seldom able to reach the germ of truth which produced the great mass of mythological romance.†

Strabo, Vitruvius, Diodorus Siculus, and Tacitus, all speak of the indications of the igneous origin of this region of Southern Italy: Seneca also detected the true character of Somma (B.C. 1 to A.D. 64), and pointed out that its crater had thrown out more than its own mass of earthy matter, "being, in fact, a channel for the fire, but not its food."

By a careful study of volcanic mountains, we are enabled readily to perceive that they possess a marked similarity, their characteristic form being a cone, truncated at the summit by a funnel-shaped cavity or crater. The cone is found to be built up of ashes, scoriæ, and other loose materials ejected from the crater, and deposited in layers, which are thickest near the rim, and consequently attain a steeper angle as the cone increases in height. These loose materials are often bound together by outflows of liquid mud, or lava, and the percolation of rain-water, acting on the light tuffs and loose volcanic sand, converts them into a heavy and compact rock.

These alternating layers of ashes, lava, scoriæ, and mud, afford an interesting illustration of *subaërial* stratification resembling marine and fresh-water deposits, and, like them, often rich in organic remains.‡

But no marine or fresh-water deposits, however formed, could have preserved for nearly two thousand years the rich treasures of Roman painting and ceramic art, in all their freshness and beauty, which the buried cities of the Campania have revealed to us.

Liquid lava streams seldom issue from the cone of eruption, more frequently they make their escape from lateral vents at low levels. When lava rises and overflows the crater, it usually breaks down a portion of the wall, and so makes its escape.

Fragments of melted lava ejected from the cone harden instantly on their surface, while the interior becomes vesicular from the expansion of the gases and minute particles of water disseminated

* Scrope, 'On Volcanoes,' p. 189.

† The contest between Earth and Sky which the Greek fable of *Typhæus* brings before us, is locally associated with volcanic energy in the region round Naples, Ætna, and elsewhere.—Phillips, p. 2.

‡ An eruption which occurred in the island of Arran in the Carboniferous period, has covered and enclosed a forest of erect trees in volcanic matter. Professor Phillips (p. 129) mentions seeing carbonized trees in lava near the Hermitage, Vesuvius.

through the mass. The same is the case with the surfaces of lava streams.

Ascending obliquely, from the direction of Bosco Tre Case and Pompeii (writes Professor Phillips, p. 191, March 1868), "we reach a broad hot region, in which are the principal fumaroli; from these quite lately—last night—lava was flowing freely, now barely moving under a solid crust of pipy or cellular rock, deep sunk below the rest of the surface, or merely glowing in deep cavities, and yielding reluctantly to the pressure of a pole, which instantly takes fire. Beneath our feet, however, for considerable spaces, the ground is really fluid, only crusted over by the partially coherent and very partially cooled scoriaceous blocks. Removing these, where practicable, by the help of a pole, we see the sullen red lava below. The quickness of the consolidation of the surface of lava is remarkable; we stand on the solid crust, over what remains of yesterday's current, in a deep canal, which not long since ran full of melted rock; on this very hot surface it is requisite to keep in motion, if one has any regard for English shoes, but there is no other inconvenience.

"The air is hot, somewhat like that in the vicinity of iron-furnaces—which seems, whether it be so or not, a little deficient in oxygen, but no smell of sulphur, in any combination, and no fumes of hydrochloric acid."

The products issuing from the crater of Vesuvius are extremely various, as also are the conditions under which they are ejected. They may be roughly grouped under three heads, namely: 1st, Gaseous; 2nd, Liquid; 3rd, Solid. Under the first we may include carbonic acid, sulphuretted hydrogen, free hydrogen, hydrochloric acid, and nitrogen; under the second, liquid lava and streams of boiling water often charged with fine mud; the third includes ashes, pumice, lapillo, puzzolana, and volcanic bombs.

The gases referred to have been noticed in the exhalations from the fumarole of the lava of Vesuvius, and escaping from the numerous crevices in the sides of the vent after the termination of an eruption.

Lava-rocks, although differing more or less in mineral character, are all found, upon analysis, to be composed of silicates of alumina, or magnesia, with some protoxide of iron, potash or soda, and lime.

The texture of the great bulk of them is stony and granular, often highly crystalline; the component crystals of felspar, augite, or hornblende, mica, olivine, and perhaps quartz, being, though interlaced and interpenetrating, occasionally as distinct and large as in granite.*

* Scrope, chap. vii., pp. 110 and 114.

Mr. Lobley furnishes us in his Appendix * with a list of the minerals found about Vesuvius and Somma on the authority of Professor Scacchi. Of these thirty-three occur in Somma, four in Vesuvius, four others are common to the lavas of both, and two were obtained from the fumaroles.

This great disparity in the relative numbers of mineral species met with in Somma and Vesuvius has a most important bearing on their origin in volcanic rocks, and confirms the opinion generally held by mineralogists, that a very large proportion of them owe their origin to a slow process of disintegration and re-combination of the constituents of volcanic tuffs, and lavas, in which rain-water acts a most important part as carrier.

The above opinion chiefly refers to those compound minerals which form the great bulk of Professor Scacchi's list, and does not in the least invalidate the observations of Bischoff, Darwin, Forbes, Monticelli, and Covelli, as to the formation of crystals of olivine, quartz, albites, leucite, &c., previous to the emission of lava, or whilst flowing at an exceedingly high temperature.

The most glassy and semitranslucent varieties of lava are known by the name of "obsidian." It does not occur in this condition around Vesuvius, but is abundant in the Lipari Islands, Mount Ararat, &c.

Large tracts in Mexico (called *Malpais*) are covered with "obsidian," and of it (as from the chalk-flint in Western Europe) the worshippers of the sun manufactured their knives, &c., which were still in use at the time of the Spanish conquest.

So long ago as 1825, Mr. Scrope arrived at the conclusion that the mobility of the solid component particles of liquid lava was not due to the mass being in a state of molecular fusion, in which condition it never occurs—subaërially,—but to the presence of an interstitial fluid disseminated through the mass, and that this fluid was water in a highly comminuted condition. This conclusion he seems to have arrived at from observing that the incandescent lava at the moment of its exposure and in the act of consolidation always gave off abundance of steam.

This hydro-igneous theory of lava has since been remarkably confirmed by the microscopic investigations of Mr. Sorby.†

The hard materials ejected from the crater are only diverse conditions of lava. Thus, when by the violent ebullition in the crater a more liquid portion of lava is shot up into the air, it assumes a globular or pearshaped figure, and is known as a volcanic "bomb." Other fragments of lava projected at a slightly lower temperature possess ragged, tattered shapes, and are full of vesicles; the heavier are called "scoriæ," the lighter "pumice."

* 'Volcanoes of Central France,' pp. 5[illegible] and 55.

† 'Quart. Journ. Geol. Soc.,' vol. xiv., pp. 453–500.

The smaller fragments shot up vertically into the air are reduced by mutual friction to a sort of gravel called "lapillo;" still further comminuted into sand "puzzolana," and when reduced to fine dust, *ceneri*, or "ashes."

The distance to which these finely-divided ashes have been carried is prodigious. During one of the early eruptions of Vesuvius, A.D. 472, its ashes were carried as far as Constantinople, where the singular event was afterwards commemorated annually on the eighth of the Ides of November.

Among the sublimated mineral products of Vesuvius and its neighbourhood we must not omit to mention Sulphur; it enters most largely into the composition of volcanic mineral products, and also occurs in a pure state deposited in joints and fissures, especially round the remarkable crater called the Solfatara, near Pozzuoli, one of the all-but-extinct volcanic vents of the "Campi Phlegræi," west of Naples.

Vast beds of this mineral (deposited from the vapours of sulphuretted hydrogen) occur both in Iceland and Sicily, and are of great commercial value.

We come then to the active agent in all volcanic outbursts—Water. "Water," says Mr. Scrope, "we know is converted into vapour only at temperatures increased in proportion to the increased pressure to which it may be subjected; and when altogether hindered from communication with the atmosphere, as in a Papin's digester, or other closed vessel, may be made red hot without expanding into vapour.* The moment, however, that an opening is made in the enclosing vessel, reducing the pressure to that of the atmosphere only, it flashes instantly into steam with explosive violence. The same effect of course must take place in an imperfect liquid or paste composed of water and any solid matter in mechanical suspension or mixture, such as flour, clay, sand, or any other granular substance."

* The *Annales de Chimie*, II., xxi. and xxii., record the experiments of Cagniard de Latour on the expansion of liquids under pressure.

De Latour partially filled some strong glass tubes with water, with alcohol, with ether, &c., and furnished them with gauges, and hermetically sealed them. He then cautiously raised the temperature. The alcohol (sp. gr. 0·844), which occupied two-fifths the capacity of the tube, gradually expanded to double its volume, and then suddenly disappeared in vapour, at a temperature of 497° Fahr.; it then exerted a pressure of about 119 atmospheres.

Water was found to become gaseous in a space equal to about four times its original bulk, at a temperature of about 773° (that of melting zinc). So great was the solvent power of water on glass, at this high temperature, that the addition of a little carbonate of soda was necessary to diminish the action on the glass, which frequently gave way until this expedient was adopted. As the vapours cooled, a point was observed at which a sort of cloud filled the tube, and in a few moments after the liquid suddenly reappeared.

From these experiments it would appear that there is a point in the temperature of every liquid at which no amount of pressure is sufficient to retain it in the liquid form.

Having thus seen the potency of water under pressure as the motive agent, and having the assurance of all observers, that water is always present, we may conclude beyond doubt "that the rise of lava in a volcanic vent is occasioned by the expansion of volumes of high-pressure steam, generated in the interior of a mass of liquefied and heated mineral matter within or beneath the eruptive orifice."

During great eruptions much forked lightning has been observed, darting forth in frequent flashes from the rising column of smoke and ashes. Mr. Scrope thinks that the intense mutual friction in the air of the ejected solid matter is sufficient to generate it; Professor Phillips, on the other hand, suggests that its occurrence is due to the rapid evaporization taking place and the vast quantity of steam liberated producing electric tension in a high degree.*

Professor Phillips mentions the observations of Professor Pilla, of Pisa, as to the occurrence of *flames* during volcanic eruptions. He evidently thinks them deserving of full credit, although he admits that in the majority of cases the light emanates from the surface of incandescent lava. We doubt one part of Professor Pilla's observation, that "Hydrogen was perceived *by the* smell!"† Surely this should read "*Sulphuretted* Hydrogen."

The theories as to the source of volcanic heat are many and various, but the one which may be said to claim the largest share of support is that which attributes the phenomena of volcanoes and earthquakes to the reaction of the interior of our planet upon its uppermost strata.

A volcano therefore exists only where there is a permanent connection between the interior of the earth and the atmosphere.

That such interior possesses a very high degree of heat is shown, not only by the state of fusion in which lava issues from volcanic vents, but also because, in proportion to the depth, there is a gradual increment of temperature observable so far as the solid crust has yet been pierced by artificial means.

Mr. Hopkins nearly thirty years ago, and subsequently Archdeacon Pratt and Sir William Thomson, have condemned as untenable, and contrary to the known laws of precession and nutation, the notion of a globe with a moderately thick crust and a fluid interior.

In order to produce a complete accordance in the motion of the entire mass, it is necessary, according to these authorities, to assign a solid crust of at least 800 to 1000 English miles in thickness.

Can any one believe that lava is pressed up through channels of that length?

* P. 144. † P. 151.

M. Delaunay has, however, clearly shown that "there is a fundamental error—not in the mathematical formula, but in the condition assumed, namely, that the interior is filled with a free-flowing liquid rock."

"The interior fluid can only be of the nature of lava, and that, when examined at the surface, however fresh, is a very intractable mass, flowing indeed as does thick honey, pitch, or slag; incapable of moving at the very utmost above a few miles an hour even on a slope of 30°, and on ordinary slopes only one mile, half-a-mile, or even thirty or forty feet in an hour. The problem solved by Mr. Hopkins, looked at in this light, does really not settle anything as to the thickness of the crust of the earth."

"The globe is continually, though very slowly, losing heat; it grows cooler in a very small degree, and suffers contraction in the same small degree." . . . "From what we certainly know of the constitution of the crust of the globe, it is of unequal strength to resist change of form in different parts. The weakest part must yield, and if by local yielding the general pressure may be satisfied (which is equivalent to supposing the general pressure determined to a small area), the displacement of a small tract may be extremely great, and the rocks there be bent into arches or broken by faults. If we are right in our views of the history of the globe, very many epochs would arise, when, first in one region, then in another, lines or areas of relative weakness would be depressed into concave seas, and receive a long series of deposits; and at other times the same areas or parts of them might be re-elevated, producing end-pressures and violent local flexures or fractures."

With these extracts from Chapter XII. of Professor Phillips's book we must now conclude this brief sketch of Vesuvius, hoping some day to be able to look at the probable connection between lines of volcanoes and volcanic centres and old volcanic areas now extinct, in other parts of the world.

IV. THE ARTIFICIAL PRODUCTION OF ICE AND COLD.

By Dr. B. H. Paul.

The application of heat for cooking food has been considered one of the most obvious characteristics by which man is distinguished from the lower animals, and there is even still greater reason for regarding the application of this physical agency for various economic and industrial purposes, as being one of the circumstances most important in determining the difference between

civilized man and savages, and most conducive in various ways to the spread of civilization.

In most of the industrial arts the application of heat is involved in some one or other of the operations to be performed. Through the medium of vaporized water it is the principal means of locomotion on land and by sea, as well as the chief source of motive-power; while in the extraction and working of metals and in most productive arts, involving chemical alteration of raw materials, it is essential for bringing about the various changes to be effected. But though chemical alteration is in many cases the object to be attained in manufacturing operations, and then the application of heat is the means by which that change is facilitated, there are some cases in which it is desirable to hinder or prevent the chemical changes to which certain materials are liable even within the ordinary range of atmospheric temperatures. Thus, for instance, all articles of food, and especially those of animal origin, when kept for any length of time at the ordinary temperature, undergo a chemical change which renders them unfit for use. They pass into a state of putrefaction or decay, and are gradually resolved, under the influence of atmospheric oxygen, into the simplest forms of combination their elements are capable of assuming. For this change a certain temperature is essential, and though it probably cannot be prevented altogether, it is very considerably hindered by a reduction of temperature. Thus, for instance, in Siberia, the carcasses of mammoths have been found in a very perfect state of preservation, notwithstanding the vast lapse of time they have been buried in the frozen soil. In like manner meat, and game, or fish may be preserved for a long time quite fresh by keeping it at or below the temperature of freezing water.

For this and other purposes which require a low temperature, and where it is desirable to abstract heat instead of applying it to any substance, ice has been largely employed, and the importation of ice into this country from higher latitudes has become a very large trade since the year 1840.

Ice acts as a cooling agent in virtue of the physical fact that, in common with all solid substances, it requires an expenditure of heat for its conversion into the liquid state. The heat thus applied does not produce any elevation of temperature, but as the ice melts it disappears, so far as the indications of the thermometer will show, and there remains a quantity of water of the same temperature as the ice itself. Thus when ice or, still better, snow is mixed with three-fourths its weight of boiling water, the water remaining after the ice has melted, has a temperature of 32° Fahr., the same as the ice itself; the quantity of heat in the boiling water, corresponding to the interval of temperature between 32° and 212° Fahr., having been rendered latent, or expended in effecting the liquefaction of the ice. It is in this way that ice cools water, air, or any other substance

it is brought in contact with, which has a temperature higher than 32° Fahr. Hence it will be seen that refrigeration, or the production of cold, is simply a manipulation of heat. It is an operation in this respect perfectly analogous to the production of a high temperature, in so far as both processes consist in the transfer of heat from one substance to another, and are subject to the same general laws. They are however reverse processes. Thus in generating steam, heat produced by the combustion of fuel is communicated to water. In making ice, on the contrary, heat is abstracted from water, and in this process the water which is cooled corresponds to the fuel burnt in generating steam, or in converting any other substance into vapour. Just in the same way that the fuel in burning yields its heat to the substance vaporized, so does the water, in making ice, yield its heat to some other substance capable of receiving it.

This is the nature of the work to be done in making ice, and it is now necessary to consider the amount of that work requisite for producing a given quantity of ice.

Water at the temperature of 60° Fahr. contains an amount of heat greater than that contained in an equal weight of ice at 32° Fahr. to the extent of 170·65 heat units* for each pound, consequently to convert water at 60° Fahr. into ice, it is necessary to abstract that amount of heat from it. Thus to produce a ton of ice the quantity of heat to be abstracted from water at 60° Fahr. amounts to

$$\overset{\text{Heat units.}}{382{,}256} = \overset{\text{lbs.}}{2240} \times 170 \cdot 65.$$

This is a quantity of heat not more than about one-eightieth part of that capable of being generated by the combustion of a ton of ordinary coal.

The means by which this amount of heat may be abstracted from water consist in producing some physical change involving an expenditure of heat, and doing this in such a way that the heat required for, and applied to that purpose, is abstracted from the water to be cooled and frozen. The conversion of any substance into vapour is a change of this kind, which involves an expenditure of heat similar to that taking place in the melting of ice. The amounts of heat thus absorbed by various substances in vaporizing are as follows:—

	Latent heat per lb. Heat units.	Authority.
Water	966·1	Regnault.
Liquid ammonia	900·0	Favre and Silbermann.
Alcohol	364·3	Andrews.
Ether	162·8	Andrews.

* The unit of heat here referred to is the quantity of heat required to raise the temperature of a pound of water from 40° to 41° Fahr., or one degree of temperature.

The amount of heat thus disposed of and rendered latent in the formation of steam from water is considerably greater than that existing in the latent condition in liquid water, or, what amounts to the same thing, that expended in melting ice; but the vaporization of water cannot be applied as a means of refrigeration to any great extent, because under the ordinary atmospheric pressure it does not take place readily or with sufficient rapidity at temperatures much below the normal boiling point, or 212° Fahr., and even when the pressure is removed by means of an air-pump, the vaporization of water proceeds very slowly at low temperatures. There are, however, other substances which vaporize readily under these conditions: and, for this reason, they are specially suited for artificial refrigeration, although the amounts of heat expended and rendered latent in their vaporization are less than in the case of water. Ether, alcohol, and liquid ammonia are substances of this kind; and, according to the foregoing data, expressing the latent heat of their vapours, the quantities of each of these substances which would have to be vaporized, in order to produce a ton of ice from water at 60° Fahr., or to produce a refrigeration equivalent to the melting of a ton of ice, would be:—

	lbs.
Ether	2,348·009
Alcohol	1,049·272
Liquid ammonia	424·728

From this comparison it will be seen that the expenditure of heat accompanying the vaporization of liquid ammonia is much greater than it is in the case of alcohol or ether, and that in this respect it is the most powerful as a refrigerating agent. But the amount of heat rendered latent in the vaporization of any substance is not the only, or even the chief point which determines its efficiency as a refrigerating agent. The degree of facility with which a substance vaporizes at low temperatures is of still greater importance, as will be evident from the following table, which gives the tension of the vapours at different temperatures below the boiling-points of the liquids under normal atmospheric pressure:—

		Ammonia.	Ether.	Alcohol.	Water.
Normal Boiling-point.		28°	95°	172°	212° F.
	° Fah.	inches	inches.	inches.	inches.
Tension of vapour in inches of Mercury at	104	463·64	35·81	5·26	2·16
	68	254·61	17·06	1·75	·68
	50	181·58	11·28	·96	·36
	32	124·52	7·22	·50	·18
	− 4	55·03	2·66	·13	
	− 40	20·81			
	−109	9·45			

Since the tension of a vapour at any temperature is the measure of the facility with which the liquid evaporates at that temperature, it will be seen from the data in this table that, in this respect, there is a very considerable difference between the liquids there named. Here, again, the characters of liquid ammonia are such as to give it a marked precedence over all the other liquids, as a refrigerating agent, by reason of its relative capability of vaporizing at very low temperatures. This substance is in fact gaseous under normal pressure, within the ordinary range of atmospheric temperature, the boiling of the liquid being many degrees below the zero of Fahrenheit's scale; and at ordinary temperatures it requires a pressure of from eight to ten atmospheres—117 to 150 lbs. per square inch—to maintain it in the liquid state.

Alcohol, although it has a greater capability than ether of absorbing heat in vaporizing, is still inferior to ether as a refrigerating agent, on account of its being much less readily vaporized at low temperatures; and even ether evaporates so slowly at temperatures much below its normal boiling-point, that it can be used for refrigerating only with the aid of an air-pump to maintain the requisite rate of vaporization.

Liquid ammonia is therefore by far the most efficient material to use for this purpose, not only on account of its ready vaporization at low temperatures, but also because its power of absorbing heat in that change is but little inferior to that of water.

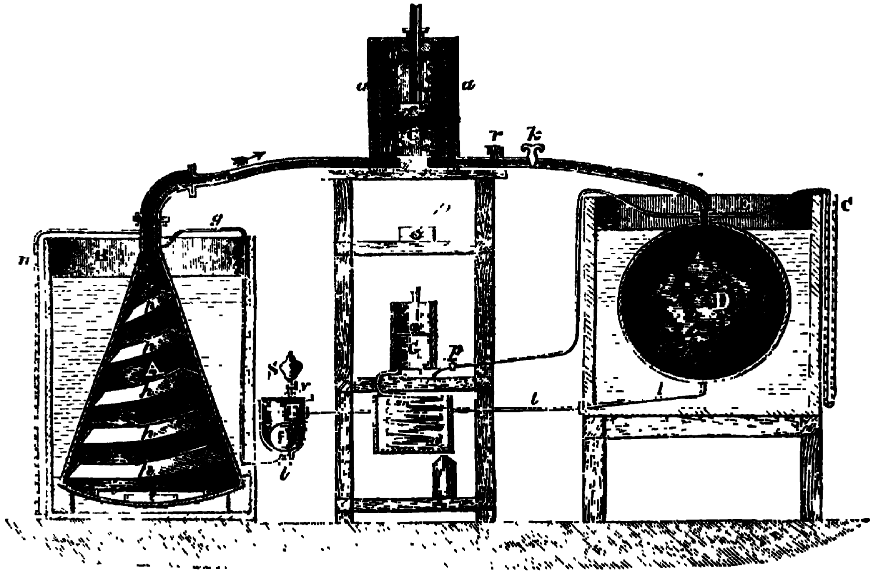
Another process, in which heat is expended and rendered latent, is the expansion of air. The amount of heat thus absorbed is at the rate of ·069, or about $\frac{1}{14}$th of a heat unit for each pound of air expanded to the extent of ·002035, or about $\frac{1}{490}$th of its volume at 32° Fahr. under normal pressure. If therefore air be compressed, say to one-tenth of its bulk, and, after being cooled to a low temperature, it be allowed to expand in such a way as to perform mechanical work, such as moving a piston, there is an expenditure of heat proportional to the resistance overcome and to the degree of expansion. Consequently the temperature of the gas is reduced during the act of expansion, and this effect may be taken advantage of for purposes of refrigeration. The chief disadvantage of this method consists in the great expenditure of power requisite for compressing the air, which involves a large consumption of fuel.

From what has been stated, it will be apparent that at present the choice of a refrigerating agent for producing ice or great degrees of cold, lies between ammonia, ether, and air, and that ammonia presents the greatest advantages for this purpose.

The expansion of compressed air appears to have been the means first adopted for making ice, by Dr. Gorrie of America; and in this country ether was the material employed in one of the

earliest ice-making machines invented by Harrison, in 1856.* This was a very simple, but rather crude arrangement, represented by Fig. 1, and consisting essentially of an air-pump, C, connected with

Fig. 1.



an evaporating vessel or refrigerator, A, on one side, and with a condenser, D, on the opposite side, so that, by the action of the pump, ether was continuously vaporized in the refrigerator, while at the same time, the vapour formed was withdrawn and forced into the condenser, where it was liquefied, and then returned to the refrigerator by a lateral pipe furnished with a valve.

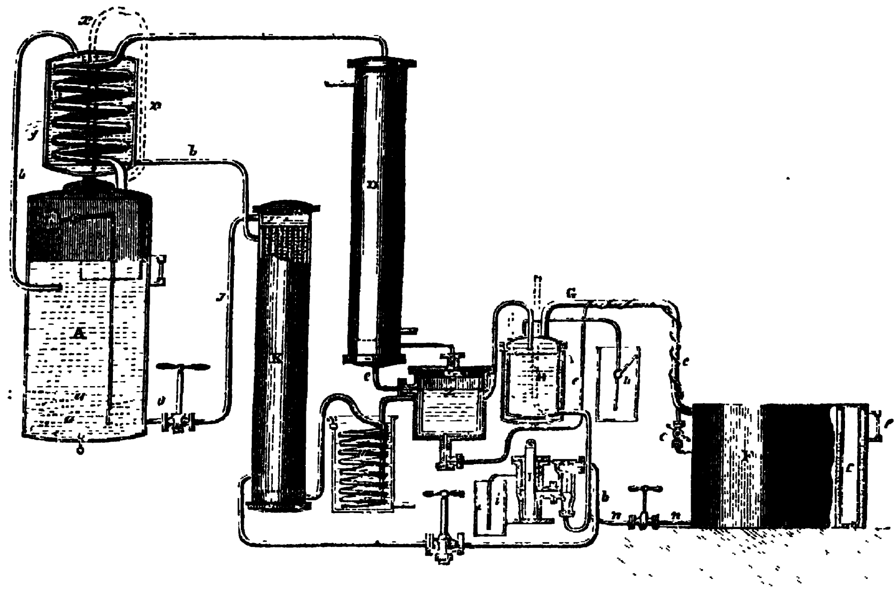
The fundamental principles on which this apparatus was constructed were correct, but there appear to have been several serious errors made in their application, and the plan did not come into use in this country. The ether machine was afterwards improved by Messrs. Siebe in 1862,† and they have since applied themselves specially to the manufacture of these ice-machines. Most of those which have been made were for India and other hot climates, where it has been found more advantageous to make ice by artificial refrigeration than to import it from America, owing to the large amount of waste by melting during the voyage through warm latitudes.

In the year 1860 another apparatus was invented by M. Carré‡ of Paris, in which a very strong solution of ammonia was used as the refrigerating agent. The arrangements of this apparatus provided for the condensation of the ammonia vaporized in the refrigerator, in such a way that it was used over and over again, and the operation of the apparatus was continuous, as in the case of the

* Specification, No. 747. † Specification, No. 782. ‡ Specification, No. 2503.

ether machine. The woodcut, Fig. 2, represents this apparatus. A strong, vertical boiler, A, is charged with a concentrated solution

Fig. 2.



of ammonia, to which heat is applied under a pressure of eight or nine atmospheres—100 to 135 lbs. per square inch—and the mixture of gaseous ammonia and steam produced, passes off through an ascending coil of pipe, B, attached to the upper end of the boiler, into a tubular condenser, D, surrounded by cold water, where the distillate is cooled and liquefied under the pressure above stated. The condensed liquid collects in a receiver, *z*, and thence passes by the pipe *e e e* into the refrigerator F at a rate which is regulated by a special contrivance.

The refrigerator F consists of a close vessel with tubes, *f*, closed at the bottom and open at the top, fitting tightly into the cover, so that the liquid ammonia surrounds them. Into these tubes cylindrical vessels are placed, containing the water to be frozen. The upper end of the refrigerator is connected by means of a pipe, G, with a vessel, H, within which the gaseous ammonia discharged from the refrigerator comes in contact with a continuous supply of cold water and is thereby absorbed, while the solution of ammonia produced is removed from the bottom of the vessel H by the pump I. In this way the gaseous ammonia is removed from the refrigerator and the pressure kept so low that the liquid ammonia is vaporized continuously, thereby abstracting heat from the contents of the tubes *f*.

The solution of ammonia produced in the absorber H is forced by the pump I through the pipe *b b* into the outer casing of a.

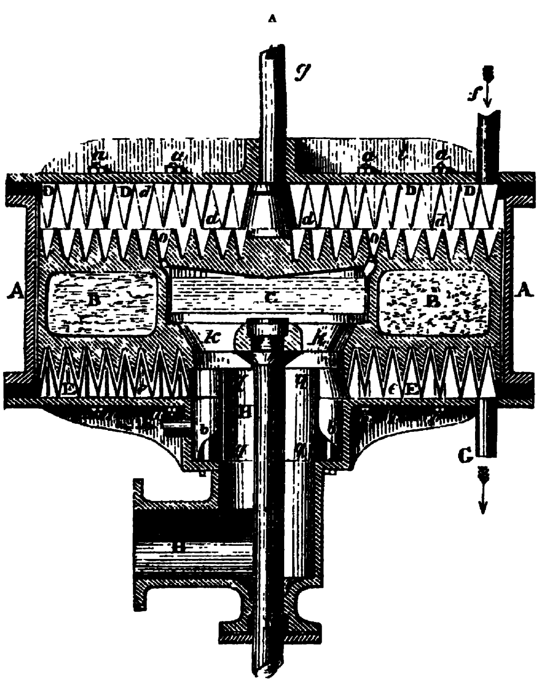
tubular vessel, K, called the regenerator, through the tubes of which hot water exhausted of ammonia flows in the opposite direction from the boiler A. Here an interchange of temperature takes place, the solution of ammonia becoming heated while the exhausted liquor is cooled. The solution of ammonia, thus heated, then passes on into the closed vessel above the boiler and containing the coil B, where it is still further heated, while the gaseous ammonia and steam within the coil B are partially cooled and condensed, and it then flows by the pipe *b* into the boiler A, to serve for a repetition of the process.

The hot liquor exhausted of ammonia meanwhile flows from the boiler in a regulated current through the pipe J into the tubes of the regenerator K, thence through a cooling worm, *m*, surrounded by water, where its temperature is sufficiently reduced, and then passes into the absorber H, furnishing the supply of water for dissolving the ammonia as already described.

This machine has been largely used in the south of France for effecting the crystallization of salts by cooling, and several have been sent out to India for making ice.

In 1862 Mr. Kirk,* of the Bathgate Chemical Works, invented a machine in which the alternate compression and expansion of air was applied as the means of refrigeration, on the same principle as Stirling's air-engine for obtaining motive power. This machine, which is represented by Fig. 3, has been used in paraffin oil works for effecting the separation of solid paraffin from the oil; it has also been worked at Messrs. Flower's brewery at Stratford-on-Avon, and one has been sent to China for making ice. The arrangement of the machine is very good; but for making ice it is expensive, on account of the relatively large expenditure of power required. Messrs. Mort and Nicolle,† of Sydney, in Australia, have quite recently patented another apparatus, in which the expansion of cold compressed air is proposed to be applied; but the principle on which it

Fig. 3.

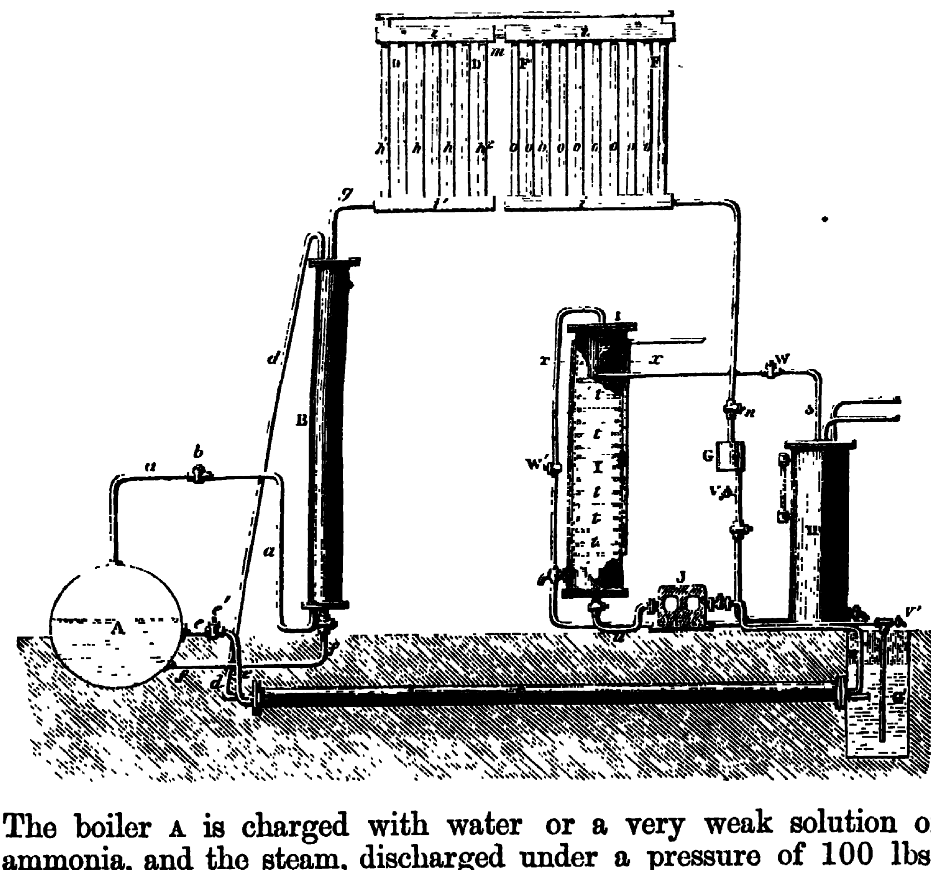


* Specification, No. 1218. † Specification, No. 3278.

is based appears to be erroneous, and it is not likely to be effective for refrigeration, besides which their apparatus is far too complicated in its arrangements. Several other patents have been taken out for ice-making machines, but those already mentioned are the principal ones which have been tried.

An improved form of the ammonia apparatus, which comprises some novel features of very great importance in regard to the use of that material for refrigeration, was patented by Mr. Reece * in 1867. The arrangement of this apparatus is shown by Fig. 4.

Fig. 4.



The boiler A is charged with water or a very weak solution of ammonia, and the steam, discharged under a pressure of 100 lbs. per square inch, passes by the pipe *a a* to the bottom of a Coffey's analyzer, B, consisting of a tall columnar vessel with a series of plates arranged one above the other inside. Into the top of this vessel a concentrated solution of ammonia is pumped continuously, and in descending from plate to plate it meets the ascending current of high-pressure steam, the effect of their contact being to convert the ammonia into gas, while the steam is condensed and flows back

* Specification, No. 1621.

again to the boiler A. The gaseous ammonia passes out of the analyzer by the pipe *g* into a tubular rectifier, D D, where the remaining steam is condensed and separated, while the ammonia passes on through a condenser, F F, where it is liquefied, and then flows through the pipe *e* to the refrigerator, H, the supply being regulated by a cock, *n*.

Meanwhile a regulated current of spent liquor passes from the boiler into a long tube, C, called the heater, fitted with an internal set of tubes, through which the concentrated solution of ammonia is forced by the pump J, into the top of the analyzer. By this means the solution of ammonia is heated, and at the same time the hot liquor from the boiler is sufficiently cooled to be supplied to the absorber I, into which it is forced by the pressure of the boiler, through the pipe *x x*, fitted with a cock, *w*, to regulate the supply. In the absorber I this water becomes saturated with gaseous ammonia discharged from the refrigerator H, and the resulting strong solution of ammonia is then pumped out into the analyzer.

The important feature of this arrangement consists in the application of the analyzing column B, and the rectifier D D, by which it is intended that the dehydration of the ammonia should be carried so far that the condensed liquid passing into the refrigerator may be practically free from water, while in Carré's apparatus the liquid supplied to the refrigerator contains 25 per cent. of water, and only 75 per cent. of actual ammonia.

The effect of this difference upon the working of the apparatus would be very great. Thus, for instance, the distillate passing from the boiler of Carré's apparatus, is separated into 95 per cent. of a liquor containing 25 parts of ammonia—which after being cooled is used for supplying to the absorber—and 5 per cent. of a distillate consisting of $\frac{3}{4}$ ammonia and $\frac{1}{4}$ water; which passes through the condenser without any further separation of the water. Therefore only $\frac{3}{4}$ of the liquid supplied to the refrigerator is ammonia; and since water, at the temperature of from $-22°$ to $-40°$ Fahr., which is produced in the refrigerator, is capable of dissolving and retaining in solution its own weight of gaseous ammonia, only two-thirds of the ammonia in the liquid supplied to the refrigerator will be available for refrigeration, the remaining third being retained by the water in that liquid, so that there will be a residuum of solution of ammonia, which must be run off from time to time from the refrigerator. Therefore since the effective refrigeration in an apparatus capable of making 5 cwt. of ice an hour from water at 60° Fahr., must be equivalent to the vaporization of 106 lbs. of ammonia within that time, it would be requisite to produce in the condenser a distillate at the rate of 212 lbs. per hour, for of this quantity 53 lbs. will be water, and that water will retain 53 lbs. of ammonia in solution, leaving only 106 lbs. available for refrigera-

tion. Then, since the cooled exhaust-liquor, as introduced into the absorber, already contains 25 per cent. of ammonia, it will dissolve only $\frac{1}{50}$ of its weight more of ammonia; and consequently to maintain the required rate of vaporization it will be necessary to supply at the rate of 200 gallons exhaust-liquor per hour to the absorber,* and to pump nearly one ton of ammonia solution per hour into the boiler, against a pressure of ten atmospheres, which will require an expenditure of power to the extent of $\frac{1}{2}$-horse power per hour.

In the apparatus devised by Mr. Reece, on the contrary, it is proposed that the ammonia solution should be separated by the operation of the analyzer into 75 per cent. of liquor, containing five parts of ammonia, which is to return to the boilers, and into 25 per cent. of gaseous ammonia, which after being completely dehydrated in the rectifier, is to be delivered to the refrigerator almost entirely free from water. In this case, therefore, $\frac{5}{6}$ths of the ammonia distilled would be available for refrigeration, while in Carré's apparatus not more than $\frac{1}{21}$th of it is available. Then, since the exhaust-liquor in Reece's apparatus would contain only 5 per cent. of ammonia, instead of 25 per cent., as in Carré's apparatus, it would be capable of dissolving a further 20 per cent. Consequently for the same amount of work only $\frac{1}{5}$th as much would be required as in Carré's apparatus, and there would be only $\frac{1}{5}$th as much solution of ammonia to be pumped back into the analyzer.

These are advantages of a very striking and important nature, and, if realized practically, they would offer for the first time an opportunity of utilizing to the fullest extent the great capabilities of ammonia as a refrigerating agent, in such a way as to surpass all others in efficiency.

Little has hitherto been done in the application of artificial refrigeration to the making of ice in this country; but in hot climates, remote from natural sources of ice, it has been found to work very advantageously. Apart, however, from the actual production of ice, which from our proximity to Norway can be cheaply obtained thence in great abundance, there are many other purposes for which artificial refrigeration can be of great service. In preparing salt meat, for instance, a certain degree of cold is required to enable the meat to take the salt, and in this case the use of an apparatus capable of producing cold at pleasure would do away with the expense attending the transport and storing of large quantities of ice. Again, the influence of cold in preserving meat, fish, and other provisions, is sufficiently well established to justify the belief that artificial refrigeration might be applied with great advantage, not only in the transport of such materials from the country to the metropolitan markets, so as to ensure their arrival

* See Report by Regnault, Balard, and Pouillet, 'Comptes Rendus,' 1862.

in better condition, but also as a means of compensating that uncertain and variable relation between supply and demand which sometimes renders articles of food excessively dear, and at others reduces their value to almost nothing. Large quantities of provisions are constantly being destroyed as unfit for food, on account of damage during transport, or from being kept too long, and this might in all probability be prevented if suitable means were applied to keep them cool, while being brought to market, and to store surplus supplies at a sufficiently low temperature for their preservation. Enormous quantities of fish are at times destroyed or carted on the land for manure, because, in the absence of any means of preserving an unusually large supply, it is not worth the cost of transport to market. In like manner the importation of what may be called the waste meat of the Australian colonies, South America, and of other countries, appears to depend mainly on a practical solution of the problem, whether a sufficiently low temperature for preserving the meat fresh can be maintained during the passage to England, at such a cost as would afford a profit on the trade.

Another of the purposes to which artificial refrigeration may be applied with advantage, is the brewing of beer, especially as the necessity for cooling power is of uncertain occurrence, and varies very much according to the season, so that there is too great a risk in keeping a store of ice for the purpose, to admit of its being so much practised as might be desirable. It is, indeed, remarkable that so little has been done hitherto by brewers in applying artificial refrigeration, for with the exception of Messrs. Flower, of Stratford-on-Avon, who were the first to put up a machine for this purpose, and of Messrs. Trueman, Hanbury and Buxton, who have lately put up one of Siebe's ether machines at their brewery, there is, perhaps, no other brewery where artificial refrigeration is practised.

The practical benefit of such a means of producing cold at will, without incurring the expense arising from the waste of ice kept in store, has been well illustrated by the results obtained by Mr. King, the engineer to Messrs. Trueman's brewery, during the autumn of last year. The apparatus worked there is capable of producing five tons of ice within the twenty-four hours, with a consumption of coal at the rate of ten tons per week, or about 7*s.* per ton of ice produced; and the additional cost corresponding to expenses for labour, waste of material, and interest on first outlay, would probably fall far short of the average price of ice during warm seasons, when it is most in demand, and sometimes rises as high as 2*l.* per ton. But this is not the whole of the advantage capable of being realized in such a case by applying artificial refrigeration. In many cases it is by no means necessary for

FIG. 1.

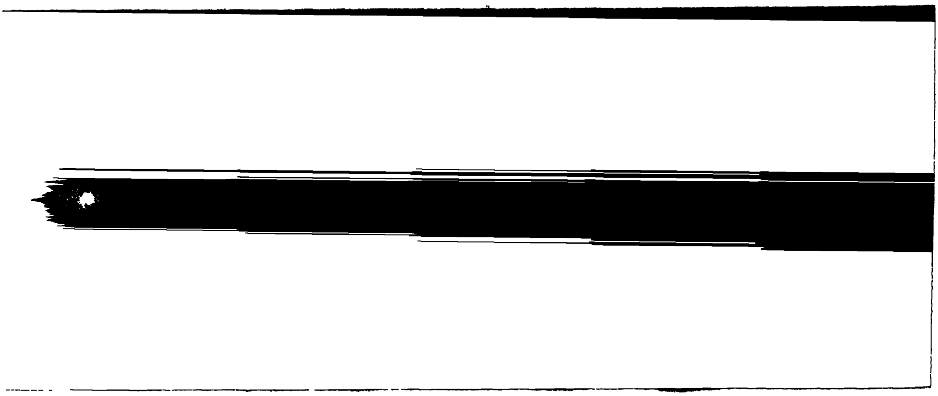


FIG. 2.

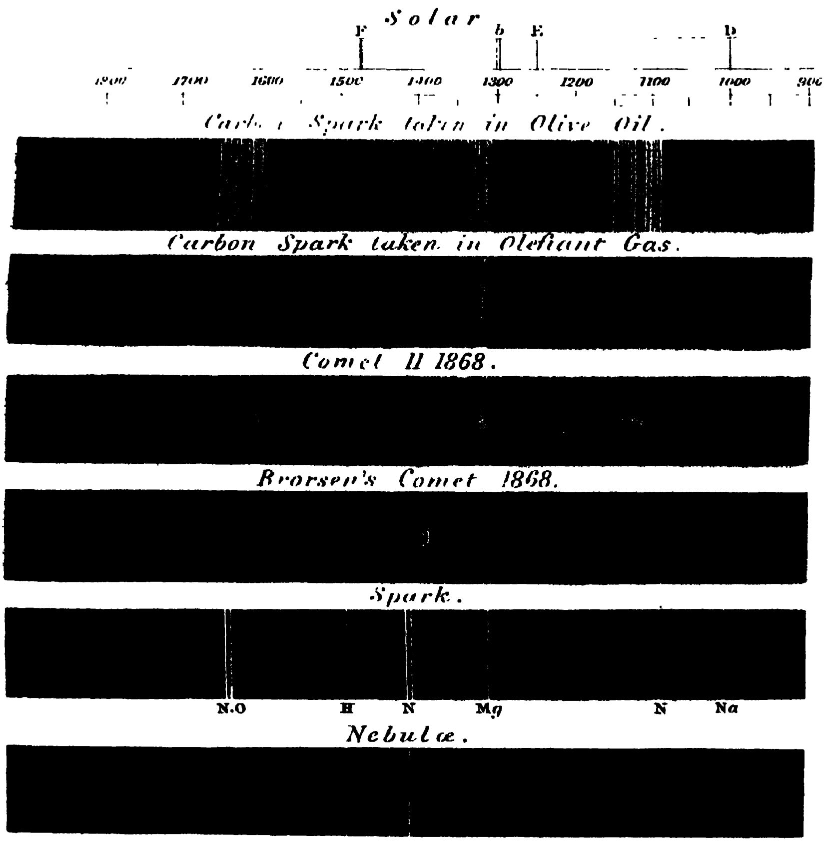


FIG. 3.

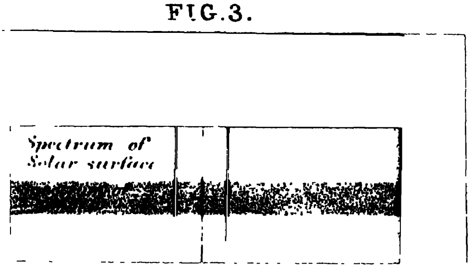
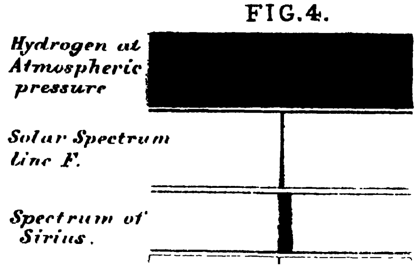


FIG. 4.



the object in view to produce ice, and, in fact, there may be a very great advantage gained by not doing so. Thus, for instance, Mr. King has, by an ingenious contrivance, arranged the working of his apparatus in such a manner that the refrigeration is applied directly to the material to be cooled, without making ice or using any refrigerating medium; and by this means he has succeeded, with the apparatus just referred to as capable of producing five tons of ice in twenty-four hours, in obtaining, during the same time and with the same consumption of fuel, an effect equivalent to the production of no less than *fourteen tons of ice*. This reduces the cost of the work done very considerably below the estimate already given, and the fact serves well to show what great benefit may be derived from the judicious application of refrigerating apparatus.

Among other purposes to which it has been proposed to apply artificial refrigeration, is the cooling of the air in dwellings, and in passenger ships passing through tropical regions;* and there are, no doubt, many other cases in which it might be usefully employed.

V. ON SOME RECENT SPECTROSCOPIC RESEARCHES.

By William Huggins, F.R.S., Hon. Sec. R.A.S.

It is the intention of the writer to give in this article an account of some of the more recent additions to our knowledge of the heavenly bodies which have followed from the application to them of that elegant and most searching method of analysis for which science is laid under lasting obligation to Kirchhoff.

The circumstance that in astronomy so large an amount of new and important knowledge has been gained, will not appear surprising when we consider how peculiarly spectrum analysis, which enables the observer to be independent of his distance from the source of light, and also of the length of time that the light has been on its way to him, is adapted for an examination of the light of the heavenly bodies, which are, for the most part, independent sources of light of a high temperature. Indeed the light of the sun, of the stars, of the nebulæ, and of comets, was written over with unread hieroglyphic characters, which, when the key was furnished by the German physicist, revealed to us information, such as it had appeared to man almost vain to hope ever to obtain.

Spectrum analysis, which consists in the skilled interpretation of the minute peculiarities by which spectra are distinguished, and

* Mr. Shand, 'Society of Arts Journal,' xvii., 97.

the mode of its application to terrestrial objects and to the heavenly bodies, are now too generally known to need description here. It may be well, however, to state the principal forms under which all spectra may be classed, and the interpretation which, in the present state of our knowledge, we are justified in giving to these different spectra, when the light has been emitted by bodies rendered luminous by a high degree of heat. It is necessary to make this distinction, as it is not purposed to describe the spectra of fluorescent and phosphorescent substances.*

The spectra of all highly heated bodies may be referred to three typical forms.

First Form.—When the continuity of the coloured band into which the light is dispersed by the prism remains unbroken either by bright or by dark lines. Now, as a general rule, such a spectrum may be interpreted as telling us that the body which emitted the light is in the solid or liquid state. Further than this, a continuous spectrum gives to us no information of the nature of the source of the light, for all solid and liquid bodies are characterized by a continuous spectrum, whatever their chemical nature may be.

Such is the interpretation which, as a general rule, and unless there should exist circumstances rendering a solid or liquid condition of the source of light highly improbable, ought to be given to a continuous spectrum. In certain cases gases may give a spectrum which is continuous. Dr. Balfour Stewart has pointed out that as gases and vapours possess a power of general or indiscriminate absorption, in addition to the elective absorption peculiar to each gas, it would follow that a gas when luminous would also emit light of all refrangibilities, producing a continuous spectrum, in addition to the spectrum of bright lines which is peculiar to the gas, and further, that the intensity of this continuous spectrum would be in proportion to the opacity of the gas.

Besides this consideration, the researches of Plücker and Frankland have shown that, under certain conditions of temperature and density, the bright lines of some gases expand, and so a spectrum may be produced which would not be distinguishable from that of the light of a solid or liquid body.

Second Form.—Spectra belonging to this class consist of bright lines. These lines tell us that the source of the light is luminous gas. Further, since, so far as observation extends, each gas and vapour is distinguished by a set of lines peculiar to itself, it becomes possible to discover if any of the substances known to us are present in the source of light. This method of analysis is not invalidated by the circumstance that the appearance of the lines may be greatly modified, or even altogether changed, under dif-

* For an account of the spectra of fluorescent and phosphorescent bodies, the reader is referred to 'La Lumière,' by E. Becquerel, vol. i. Paris, 1867.

ferent conditions of temperature and density, as is well known in the case of nitrogen, the vapour of sulphur, and some other substances, for throughout all these changes each gas behaves in a way peculiar to itself.

As far as our knowledge goes, there appears to be but one exception to the statement that a spectrum of bright lines indicates luminous gas. Bunsen found that when solid erbia is heated to incandescence, the continuous spectrum contains bright bands.

Third Form.—This type embraces all spectra in which the continuity of the colours of the spectrum are interrupted by dark lines or bands. These gaps in the spectrum, which indicate that light of certain refrangibilities is wanting, do not teach us anything of the source of light itself, but show the existence, without the source of light, of vapours at a lower temperature, which, by a selective power of absorption peculiar to them, have quenched the light of certain periods of vibration only, and have not been able to make up for the light they have taken, by light of their own. As the kinds of light absorbed by each vapour correspond precisely with the set of bright lines which that vapour emits when in a luminous state, a comparison of the bright lines of substances that are known with the dark lines seen in a spectrum will show whether the vapours through which the light has passed are those of any of the bodies with which we are acquainted. The bright spectrum, in which the dark lines occur, must be questioned for information of the source of the light itself, according to the principles stated under the first form of spectra.

The foregoing statements form the canons of interpretation by which we are to be guided in our explanation of the spectra of the heavenly bodies.

The most important recent information obtained respecting the *fixed stars* results from the application of spectrum analysis in a new direction.

Under certain conditions, which will be stated, the spectrum of a luminous body is adapted to tell us whether that body is moving towards or from the earth.

It may be well, however, to point out in how remarkable a manner this new application of prismatic analysis supplies a want which astronomers had come to regard as one that could not be met by any method of observation within our reach. The stars, though apparently so immovable that they can serve as the figures on the dial-plate of the heavens to which all sensibly moving objects may be referred—the *fixed* stars, as it is still convenient to call them, are not absolutely motionless, like fiery studs riveted in the canopy of heaven. These brilliant points are found to shift their places to a minute extent relatively to each other. Small displacements are found which must be interpreted to represent a proper motion

peculiar to each. Now, by ordinary methods of observation, that part only of a star's motion which is transverse to the line of sight can be detected, for the motion a star might have in the visual direction, either directly towards the earth or from it, would not cause any apparent change of position of the star, and would therefore remain undetected.

The method of photometry was clearly too coarse and too uncertain. Too coarse, for the eye, even when aided by suitable instruments, could not hope to distinguish the minute increase or decrease of brightness which would correspond to any velocity we could with probability assign to the stars, even if the observations were repeated at intervals of a thousand years. Too uncertain, for if the variations in the transparency of our atmosphere could be certainly eliminated, the large number of stars, of which the light is known to be variable, would forbid us to regard any alterations of brightness that might be observed, as trustworthy indications of the approach or recession of the star.

Now this radial motion of a star, which eluded our methods of observation, does record itself most fortunately in small alterations, which can be distinguished in the spectrum of its light. If the star be approaching the earth, a line, either light or dark, in its spectrum will be found to have moved from its proper place towards the blue end of the spectrum; if the star be receding from the earth, the line will have moved in the opposite direction, towards the red. The amount of shift of position produced by a star's motion will express exactly the proportion which its motion bears to the velocity of light. As the rate of propagation of light is known, the velocity of the star may be found.

The refrangibility, or the colour of a ray of light, or what is the same thing, the place in the spectrum which the light would take after it had passed through a prism, is determined by the number of pulsations or waves which meet the eye, or fall upon the prism, in a second of time. The special character which distinguishes red light from violet light consists in that the waves of red light are nearly as long again as those of extreme violet light. Now the velocity of propagation through the ether is precisely the same for all the colours of the spectrum. Red, yellow, green, blue light, emitted by a distant star, would reach the earth at the same instant, and it is for this reason that a new star, at the first moment that its light falls upon a human eye, appears of its true colour. Light travels with a velocity of about 185,000 miles in a second of time, a series of waves therefore extending through 185,000 miles enters the eyes each second. Now as it is upon the length of the waves, or upon the number contained in the series that enters the eye in a second, that a judgment is formed of the colour of the light, or the place of the light in the spectrum after

passing through a prism is determined, it follows that any circumstances which would alter the length of the waves *relatively to the observer*, or in other words cause a large number of waves to enter the eye in a second of time, would cause a change in the colour or refrangibility of the light so far as the observer was concerned. An alteration in the velocity of the propagation of light would effect a change of wave-length, not, of course, intrinsically, but as measured by the eye which i entered, or the prism through which it passed. Less than twice the actual velocity of light would cause red light to be changed into violet, and all the other colours, the yellow, green, and blue, to be raised into force of that quality which exists in the long invisible spectrum beyond the violet.

Now it is obvious that the velocity of light is virtually altered to an observer moving in the direction in which the light is travelling. If the observer advances to meet the light, the velocity with which it enters his eye is increased, a longer series of waves falls upon the retina in a second of time, each wave appears shorter, and he therefore ascribes to the light a different colour, a higher refrangibility, than he would do if he were not advancing to meet the light. There is no change in the light itself, the alteration consists in a new relation of the observer to it.

To a swimmer striking out from the shore, each wave appears shorter, and he passes a greater number in a given interval in proportion to the speed of his progress through the water. If the distance between the men in a single file of soldiers be taken to represent the length of the waves of light, the distance will be diminished to a man meeting the soldiers, for he will pass a greater number of them in a given time than if he had been standing still.

Further, since the change of refrangibility depends alone upon the continually shortened distance between the observer and the source of the light, it is obviously of no moment whether the motion of approach belongs to the observer or to the source of the light. It requires no consideration to see that an opposite change in the refrangibility of the light will be produced by a motion of recession between the observer and the source of the light.

The idea that an effect upon the refrangibility of light would be produced by a motion of the observer or of the source of the light towards or from each other, is due to Doppler, who stated at the same time (in 1841) that an analogous change should take place in sound. In 1845 Doppler's theory was put to the test by Ballot, who published a series of acoustic experiments which confirm the correctness of the theory in the case of sound.

The comparatively slow velocity of sound through the air makes it an easy matter to give to the sounding body or to the listener a relative motion sufficiently great to produce a very

sensible alteration in the pitch of the sound. In the case of light, however, which travels with a velocity of about 185,000 miles per second, it would be necessary to give to the luminous body and the observer a relative motion of 20 to 30 miles per second, even for such a minute change as could be just detected by a powerful spectroscope.*

The change in sound can be observed under many circumstances. The pitch of a railway-whistle when a train in rapid motion has passed the station of the listener is no longer the same as it was when the train was approaching. The sound of the whistle reflected from a wall is different from the sound which comes directly to the observer's ear. If two tuning-forks sounding in unison be held in the hands, and if at the same moment one hand be thrust suddenly forward and the other hand be drawn quickly backward, immediately to a listener standing in front of the experimentalist the unison will be interrupted by beats which tell of a difference of pitch produced on his ear by the opposite motions of the forks. Doppler in 1841 proposed by a similar consideration to account for the remarkable difference of colour observed in some double stars. But here he went wrong, for he overlooked the important circumstance, that if a star could be conceived to be moving with a velocity sufficient to alter its colour sensibly to the eye, still no change of colour would be perceived, for the reason that beyond the visible spectrum, at both extremities, there exists a store of invisible waves which would be at the same time exalted or degraded into visibility, to take the place of the waves which had been raised or lowered in refrangibility by the star's motion. No change of colour, therefore, could take place until the whole of these invisible waves of force had been used up; which would not be the case until the relative motion of the source of light and the observer was several times greater than that of light.

These considerations bring into prominence the conditions that must be fulfilled before the alteration of the refrangibility of light by the relative radial motion of the source of light and the observer can be employed to detect the motions in the line of sight of the heavenly bodies. It is essential, first, that we can ascertain the original colour or refrangibility of some part of the light at the moment when it left the star; and, secondly, that we can recognize

* The writer thought it might be possible to obtain an experimental illustration of the principle discussed in this article by observing an induction spark taken between electrodes of sodium placed at a little distance apart. It seemed possible that by the force of the spark the sodium, in a state of vapour, might be carried from one electrode towards the other with a velocity sufficient to alter the refrangibility of the lines of sodium when the spark was viewed in the direction in which it was proceeding. Several experiments, with a large induction coil, were made with the necessary care, but it was found that the vapour of the sodium remained very close about the electrodes, and no change of position of the lines in the spectrum could be detected.

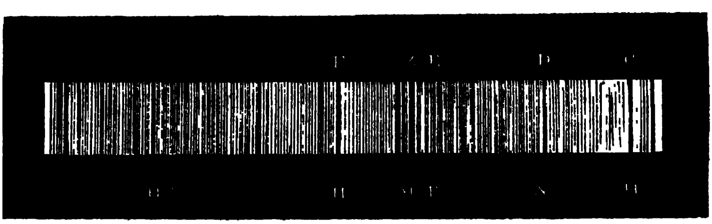
this particular part of the light again in the spectrum of the star's light.

Spectrum analysis enables us to obtain the information and to make the recognition which are necessary. When, by means of a group of dark or bright lines, we learn the presence of a terrestrial substance in the star, we possess the means of knowing with the greatest exactness the original refrangibility of those lines; and further, these dark or bright lines are objects which can be easily recognized, and can be compared directly with the lines produced by the same substance on the earth. By this method an observer can detect any minute shift from their original position which the lines may have suffered from the motions of the star and the earth.

For such an investigation it was necessary to choose a brilliant star, in the spectrum of which there were strong and very distinct lines, and which, by their coincidence as a group with the bright line of some terrestrial substance, showed that they were produced by the vapour of that substance in the star. Of all the stars which the writer had compared with terrestrial elements, when working with his distinguished friend, Dr. W. Allen Miller, Treas. R.S., Sirius appeared to fulfil most nearly these conditions.

The spectrum of Sirius (see woodcut) contains four very strong lines; two of these were found to be coincident, as seen in a spectroscope of two prisms, with bright lines of hydrogen; a third line is probably also to be regarded as a line of hydrogen. In addition to these strong lines, the spectrum is furrowed from end to end by numerous fine lines. Among these were found lines indicating the presence of sodium, magnesium, and iron. Nearly all stars of which the light is white or nearly so give a similar spectrum.

Spectrum of Sirius.

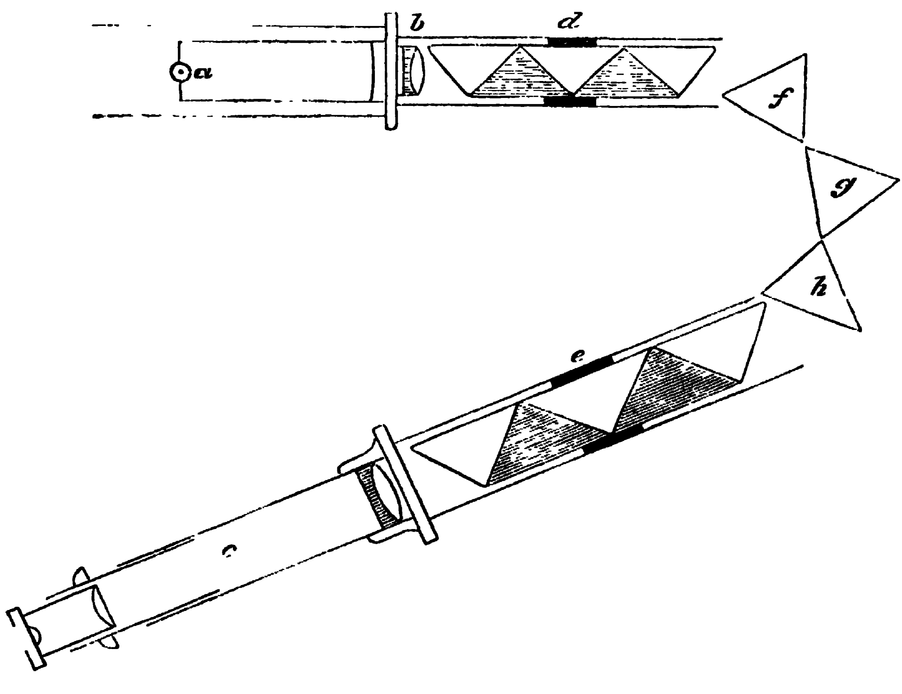


Of all these lines, however, there is only one (the strong line due to hydrogen and coincident with Fraunhofer's F) which could be seen with the necessary distinctness when the powerful battery of prisms required for this delicate investigation was employed.

It may be well here to give an answer to an objection which may suggest itself to some readers. If the line in the star is not absolutely coincident with the line of hydrogen, would not the

simple interpretation that the substance in the star is not hydrogen be preferable to the somewhat out-of-the-way hypothesis that the line has suffered a small displacement by the motion of the star? Certainly it would if we had one line only for comparison. Since, however, there are two strong lines in different parts of the spectrum, coincident, within the power of an ordinary spectroscope, with those of hydrogen, and a third line almost certainly coincident under similar circumstances, the probability is so great that hydrogen exists in the star, that we are, probably, justified in assuming that such is the case, and therefore in ascribing any very minute want of coincidence which a more powerful spectroscope may reveal, to a change which the light has undergone since it left the star.

The question then presented itself, how large a spreading out of the spectrum would be necessary in order to detect such a velocity of motion as might be expected from the observed proper motions of the few stars of which the parallax is known. The spectroscope which the writer had hitherto employed consisted of two prisms, and was competent to show a shift of position in a line equal to the distance which separates the lines D of sodium,



which would be equivalent to a velocity of about 190 miles per second. The velocities in a direction at right angles to the line of sight of the few stars, of which the distance is known, lie between twenty miles and sixty miles per second. An apparatus, therefore,

equal to about seven prisms was needed to detect the amount of motion which was to be expected.

The circumstance that the writer possessed two fine compound prisms by Hofmann, of Paris, and some other considerations, led to the construction of an apparatus of the form represented in the woodcut on the opposite page. *a* is an adjustable slit, *b* an achromatic collimating lens, of 4·5 inches focal length; *c* represents the small telescope with which the spectrum is viewed. The train of prisms consists of two compound prisms, giving direct vision, *d* and *e*, and three simple prisms, *f*, *g*, *h*. The compound prism marked *e* is permanently connected with the telescope *c*, with which it moves. The compound prism *d* is so fixed that it can be removed at pleasure when the dispersive power of the instrument is reduced from about six and a half prisms of 60° to about four and a half prisms of 60°. It was with this instrument that the observations were made; but an apparatus in many respects superior has since been constructed for the writer.

A difficulty of some importance, and which had been expected, had now to be overcome. It was necessary to contrive a method by which the light from a substance to be compared with a star could be made to pass through the prisms in such a manner that the spectrum of comparison should be with certainty in absolute coincidence with the spectrum of the star. When the light to be compared is reflected into the instrument in the usual manner, by means of a small prism placed before the slit, a very small alteration of the position of the source of the light will cause the two spectra to shift upon each other to an amount much larger than the small differences of position which were to be sought for. In the former researches of the writer this source of possible error was constantly kept in view, and guarded against by a frequent comparison of the lines of sodium reflected into the instrument with those from a flame containing sodium placed before the object-glass. When the lines of sodium, as seen in both spectra, were truly coincident, the apparatus was considered to be in perfect adjustment. This method, however, was not found to be trustworthy for the more delicate investigation now in hand, since there existed the risk of a slight accidental displacement of the spark, or of the mirror by which it was reflected into the instrument, which would produce an error much more serious with the larger dispersive power now in use.

After the trial of some other methods, an arrangement was adopted which was found to be perfectly trustworthy. Two pieces of thin glass, silvered by floating them in a silvering solution, were fixed at an angle of 45° in front of the slit, a small space of about $\frac{1}{70}$ inch being left between them for the passage of the pencils of light from the object-glass. The invariability of position of the

terrestial light relatively to the mirror was ensured by making it pass through a small hole in a plate of ebonite. This plan possessed two other important advantages. The two identical spectra of comparison were seen, one above the spectrum of the star, the other below it; and further, as the rays from the terrestrial light were divergent, they encroached a little upon the pencils from the object-glass at the slit, and caused the lines in the two spectra of comparison to overlap for a little distance the spectrum of the star. This state of things greatly assisted the eye in forming a judgment as to the absolute coincidence or not of a line in a star with that of a substance compared with it.

The comparisons, even when effected in this way, were not trusted to alone, but were checked by independent observations made when the light of comparison was placed before the object-glass of the telescope.

To return to the observations of Sirius. The only line in the star that could be successfully observed is the strong line at the position of Fraunhofer's F, which is due to hydrogen. Now this line of hydrogen is subject to great modifications under different conditions of density. Hydrogen at the atmospheric pressure gives a broad band of diffused light; it was, therefore, necessary to employ the hydrogen at a small tension. The light of rarefied hydrogen is resolved by the spectroscope into three bright lines. It is with the line at the blue extremity of the green that the comparisons were made.

In Fig. 4 of the Plate these lines are represented.

As the result of numerous observations on many nights, it was found that the narrow line of rarefied hydrogen did not coincide precisely with the dark line of Sirius, but appeared to be a little more refrangible.

After the excessive care that had been taken to eliminate every conceivable source of error, it is believed that the want of coincidence of the line in the star with that of hydrogen, may be accepted as a shift produced by the star's motion. The amount of the displacement represents a velocity of separation between the star and the earth of about 41 miles per second.

The writer then obtained evidence from experiment that the want of coincidence of the narrow bright line of rarefied hydrogen with the centre of the band in Sirius was not due to an unsymmetrical expansion of the line as the tension of the gas is increased. For this purpose a modified form of Sprengel's aspirator was constructed, and also a condensing apparatus, with which the spectra of hydrogen and some other gases were examined under different pressures. It is obvious that the hydrogen in Sirius is at a pressure considerably less than that of our atmosphere at the surface of the earth, but is more dense than the hydrogen in the solar atmo-

sphere by which F is produced. This conclusion is in accordance with the presumably enormous mass of Sirius, as suggested by its great intrinsic splendour, which, according to some calculations, is 393 times that of our sun. Some more recent comparisons of its light by Alvan Clark, however, would give a somewhat smaller proportion.

The platform from which the astronomer observes is itself in rapid motion. The earth is moving through space, in its orbit round the sun, at about 19 miles per second. The part of the earth's motion, which will be in the direction of any star, either towards it or from it, will be different for different seasons of the year, and according to the star's position relatively to the plane in which the earth moves.

At the time the observations on Sirius were made, the earth was moving from the star with rather more than half its orbital velocity; this would leave about 30 miles due to the star itself.

Another correction has to be applied. It appears probable that the whole solar system is in motion towards the constellation Hercules, with a velocity of about 4 or 5 miles per second. As Sirius is situated in a part of the heavens opposite to Hercules, its motion must be further reduced to about 26 miles per second, the remaining (about) 15 miles of separation between the earth and Sirius being due to the two causes just assigned.

The true motion of Sirius will consist of this radial motion from the earth, compounded with the transverse motion which is shown by a small displacement of the star relatively to the neighbouring stars, and is known as its "proper motion:" this apparent motion represents a velocity of the star from 24 to 40 miles per second, according to the value which is assigned to the parallax of the star, that is, according to the distance at which we suppose it to be from the earth.

There are in the proper motion of Sirius certain *periodic* inequalities which led to the prediction, that there existed a body very near to Sirius, a prophecy which received a remarkable fulfilment by the discovery of a companion star to Sirius by Alvan Clark.

We now pass to some observations on that strange and mysterious order of heavenly bodies, the *Nebulæ*. The writer's former observations showed that the prevalent opinion, that all these objects were swarms of bright stars too remote to be separately distinguishable, could no longer be maintained. A large part of these objects give a remarkable spectrum (Fig. 2, Plate), which appears to be peculiar to the nebulæ. It consists essentially of three bright lines, though in some objects a continuous spectrum and a fourth line are also present. The writer showed that within the limits of the apparatus he then employed, the brightest of the lines was coincident with the brightest of the lines of nitrogen, and the third line with

one of the lines of hydrogen. These objects were thus shown to be masses of luminous gas, of which the principal constituents were hydrogen and nitrogen.

Now it appeared possible that the application to these objects of the more powerful spectroscope, and more exact methods already described, by which the apparent coincidence of the nebular lines with those of nitrogen and hydrogen would be subjected to the test of a spreading out of the spectrum, three or four times as great as that previously employed, might furnish new information on two important points.

If the coincidence of the lines was found to be no longer maintained, then if it should be seen that both lines were, to about the same amount, a little more or a little less refrangible than the corresponding terrestrial lines, there would be reason to conclude that the want of coincidence was due to a motion of the nebula towards or from the earth. If a want of coincidence were observed in one line only, or in both lines, but in different directions, then there might be reason to infer that one or both lines were not really due to the substances nitrogen and hydrogen.

A careful re-examination of the nebula in Orion on several nights showed that the coincidence of one line with nitrogen and one line with hydrogen was perfectly maintained, a result which appears to show that the lines are really emitted by hydrogen and nitrogen; and further, that this nebula is not receding from us with a velocity so great as 12 miles per second, for such a velocity added to the earth's motion at the time would have produced a sensible shift of the lines. If, however, the nebula were moving in the opposite direction, it might have had a velocity of approach as great as 20 miles per second, for half of this amount would have been annulled by the earth's motion from the nebula.

The method of placing the spark before the object-glass brought into notice a fact of sufficient interest to be recorded. The great loss of brightness which followed from the distance at which the induction spark passing in nitrogen was observed, showed itself alike in the case of hydrogen and nitrogen by the total extinction of all the lines of the spectrum, with the exception of the one line in each spectrum which is found in the nebulæ. The obvious inquiry suggests itself whether the other lines of hydrogen and nitrogen were also originally present in the light of the nebulæ, and have been quenched on their way to us. As the nebulæ are objects of sensible size, we cannot attribute the extinction of the lines to the effect of distance alone. If one had reason to believe that the fainter lines of nitrogen and hydrogen have been extinguished on their way to us, we should have experimental evidence of the absorptive power on light, which, from theoretical grounds, was ascribed to cosmical space by Chéseaux and the elder Struve.

A fourth line has been detected in spectrum of the nebula of Orion, by Lieut. Herschel, in India, which appears to agree in position with a fourth line seen by the writer in the nebula 18 H. IV., and which is probably coincident with a line of hydrogen. The fourth line in the nebula of Orion has been also seen by Lord Rosse and by Professor Winlock, of the Harvard Observatory. These observers also suspect the existence of some other extremely faint lines.

The writer expects after a short time to continue his researches on the motions of the stars, and on the spectra of the nebulæ, with more powerful instruments than those he has hitherto employed.

In the years 1866 and 1867 the writer observed the spectra of two small *comets*. The spectra of both these objects were compound, showing that part of the light was reflected and part probably emitted by the cometary matter. Last year two comets of superior brightness appeared, which permitted a more complete analysis of their light to be made.

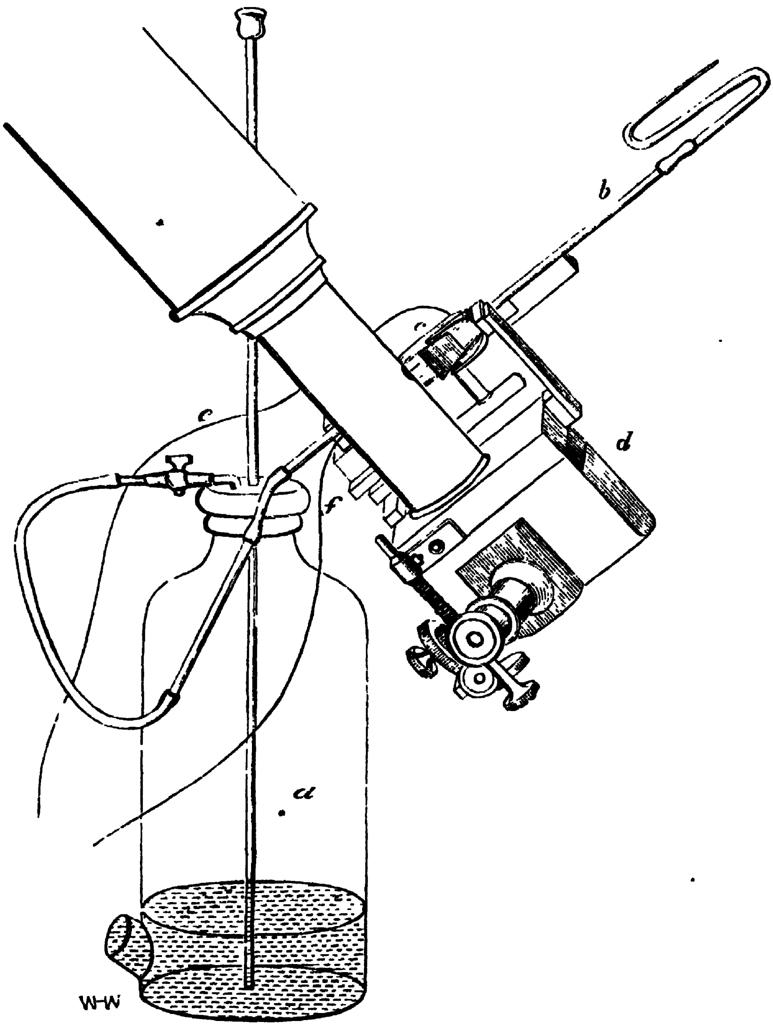
The first of these was the return of the well-known comet of Brorsen, which was examined from May 2 to May 13. The second comet, a still brighter one, was discovered independently by Winnecke and by one of the assistants at the observatory of Marseilles. This comet was observed in June.

The spectra of these comets, which consist mainly of three bands of light, are represented in Fig. 2 of the Plate. These sets of bands, though they occur in similar parts of the spectrum, are far from being identical. It may be that from the faintness of Brorsen's comet the bands could not be traced so far; but even if it were so, this circumstance would not explain the considerable difference of position which exists between the bright well-marked beginning of the middle band. The positions of the bands in the spectrum are shown by the solar spectrum which is placed at the head of the diagram.

The morning after the observations of comet II., the writer was surprised to find that its spectrum appeared to agree exactly with one of a series of the spectra of carbon, as obtained from the decomposition of various carbon compounds which the writer had prepared a few years before. Two of these spectra are given in Fig. 2. It will be seen that though the light emitted by the carbon in both cases consists of the same refrangibilities, in the upper spectrum of the diagram the bands in the spectrum are resolved into narrow bright lines, while in the second spectrum, under similar conditions of the slit and of temperature, the bands remain undivided. These spectra are given not as exclusively peculiar to the particular combinations of carbon from which they were obtained, but as types of the spectra of a wide range of carbon compounds. The upper spectrum of bright lines was obtained

by passing a powerful induction-spark between the points of platinum wires, sealed in glass tubes, through olive oil. A similar spectrum is given by the spark in cyanogen. The other spectrum of unbroken shaded light was obtained by the spark in olefiant gas.

It is with this modification of the spectrum of carbon that the spectrum of the comet appeared to agree precisely, not only in the position of the bands, but also in the special characters of the light of each band. The circumstance that in the comet's spectrum the bands become shorter as well as fainter towards the more



refrangible limit of each band was due to the arrangement of light in the comet itself. The appearance of the comet in the telescope is represented in Fig. 1; the slit was placed across the head of the comet. The greater brightness of the central spot permitted

the middle part of each band, which was due to the light of this part of the comet, to be traced to a greater distance than the marginal parts which were produced by the fainter portions of the comet.

The same evening the writer put this apparent identity of the comet's spectrum with that of carbon to the test of a direct comparison of the two spectra. For this purpose a jar of olefiant gas was prepared, and the comparison was made in the manner shown in the woodcut.

The glass gas-holder *a*, containing olefiant gas, was connected by a flexible tube with a glass tube, *b*, into which platinum wires were soldered. This tube was so fixed that the spark between the wires was suitably reflected by the small mirror *c* into the spectroscope attached to the telescope, so that the spectrum of carbon appeared directly below the spectrum of the comet.

Very careful comparisons on that evening and similar direct comparisons on a subsequent night showed that in every particular the spectrum of the comet was similar to that of the spectrum of carbon as obtained by the decomposition of olefiant gas. The lines of hydrogen which are prominent in the spectrum of the gas were not present in the comet's spectrum.

Considering that the apparent identity of the spectra rests upon the positions of three bands and also upon the special characters of the distribution of the light in them, the conclusion may, perhaps, be considered well founded, that the source of a part of the cometary light is really due to carbon.

The difficulty of accepting what appears to be the obvious teaching of these observations arises from the very high temperature necessary to raise carbon to a state of vapour; for it appears to be alone when carbon is in the condition of luminous vapour that the characteristic spectrum of the bright bands appears. A degree of heat sufficient perhaps even for this purpose has been experienced by a very few comets. A temperature less excessive might be indeed sufficient, if we were free to suppose that comets consist of some compound of carbon which is decomposed by the sun's heat.

It is right to state that phosphorescent and fluorescent bodies give spectra containing bright bands. The former phenomenon appears to be restricted to solid and highly-reflective bodies, and the phosphorescence emitted by them is not seen so long as they are exposed to light. The phenomenon of fluorescence, when a nearly transparent liquid becomes an object of some brightness by absorbing the nearly invisible rays of the spectrum, and then dispersing them in a degraded and more luminous form, is less inconsistent with the small reflective power of cometary matter.

The violent commotions and internal changes of comets when near the sun seem, however, to connect the light they emit rather with a condition of great heat.

Some further considerations and speculations relating to cometary matter, and the phenomena which comets exhibit, will be found in a paper presented by the writer to the Royal Society.*

The invisibility on ordinary occasions of the bright prominences which appear round the sun at the time of a total solar eclipse is not due to the great splendour of the solar disc, for the sun could be easily eclipsed artificially by suitable diaphragms, but to the imperfect transparency of our atmosphere, which, on this account, near the sun is much brighter than the prominences which lie beyond it. When, however, the great natural diaphragm, the moon, cuts off the sun's rays before they reach the earth's atmosphere, the screen of illuminated air no longer exists, and the fainter phenomena beyond are seen.

In order to render the prominences visible without an eclipse, it is necessary to reduce by some means the light from the air in a much greater proportion than the light of the prominences. It is possible to do so, because while the solar light of the atmosphere consists of all colours of the spectrum, the light of the prominences is made up of three refrangibilities only. Any method, therefore, which would spread out the colours, or would produce absorption on certain parts of the spectrum, would diminish the brightness of the air relatively to that of the prominences, and might render them visible.

Though to Mr. Lockyer is due the first published statement of the possibility of rendering the prominences visible by the spectroscope, the same idea had also occurred, quite independently, to the writer, and to Mr. Stone, F.R.S. The writer tried the method on several occasions without success, in consequence of not knowing in what part of the spectrum the lines of the prominences would be found. When their places had been determined approximately by the observations in India of the solar eclipse, with the same instrument, he found the bright lines at the first moment of looking for them. Nearly three years ago it occurred to the writer that the form and appearance of the objects might be seen by means of coloured glasses and other absorptive media, by which the parts of the spectrum in which the bright lines occur could be isolated, and the light of all other refrangibilities extinguished by absorption.

By this method, combined with a modified form of spectroscope, he has found that it is possible to see the outlines of these objects.

In this connection it may be well to refer to an observation made on the spectrum of a solar spot. The sun's surface, when seen under favourable conditions, consists of aggregations of bright bodies, between which are minute spaces, more or less dark, which are known as the "pores." Such is the normal state of things, but

* 'Phil. Trans.,' 1868, pp. 560–64.

temporary phenomena are of frequent occurrence, in which some of these minute pores are enormously increased in size, and become "spots." The inner portion of these spots is not uniformly dark, but contains usually a still darker spot. The writer in one instance found that the light of the inner part of a spot was about three times that of the light of the atmosphere near the sun's limb. When the light of the umbra is examined in the spectroscope the lines of Fraunhofer are foun increased in width in a small degree, as is shown in the Plate, Fig. 3. Mr. Lockyer made independently a similar observation. In April, 1868, the writer found in the spectrum of a spot that the lines C and F were not widened. This observation is of some interest, now that we know that two of the three bright lines of the prominences are coincident with the dark lines C and F.

The writer prefers not to build any speculations on these facts at present, since, in his opinion, the precise state of things which constitutes a sun-spot is not certainly known. The fragmentary character of the latter portion of the article has been owing to the writer's desire, not to omit some recent observations in this wonderful method of analysis, which promises to aid us in the solution of numerous cosmical problems hitherto deemed inscrutable, and greatly to extend our knowledge of the universe.

VI. THE FUTURE WATER-SUPPLY OF LONDON.

By C. W. Heaton, F.C.S., Professor of Chemistry in the Medical School of Charing Cross Hospital.

The long-expected Report of the Royal Commission on Water-supply will, it is to be hoped, be presented to Parliament in the course of the present session. Its publication will probably put us in possession of the most important document ever issued on this most important subject; for it is understood to contain many new and some rather startling results, in addition to the complete epitome of previously acquired knowledge, which was to be expected from the high reputation of its authors. In the meantime the public slumbers, as it generally does in England in the intervals of the periodical fits of energy in which so much of the real work of reform is done. To one whose study has brought him face to face with any of the great problems of sanitary reform, it is, indeed, a never-ceasing wonder that slumber, in the presence of such fearful questions, should at any time be possible; and he is apt to feel thankful to any monitor—even to the death-dealing cholera—that succeeds in awakening men to life and work. It is marvellous, certainly, that so enlightened,

wealthy, and practical a nation as we boast ourselves to be, can live on in peace in the midst of such foul impurity as riots on every side of us; that we can even sleep in our beds and forget that tens of thousands of our fellow-countrymen are annually falling victims to this curse of man's stupidity and sloth, to this vampire of filth which haunts our towns and villages. And our wonder is increased when we remember the ineffably disgusting nature of the filth with which we are poisoned; that we are in very truth, in many cases, drinking and breathing human fœcal matter; and that the only consolation we are offered in these cases for the nasty fact, is the comforting assurance that it is "very much diluted!"

In considering the question of water-supply, it is important to notice at the outset, that it is inseparably associated with another question, which, for this and other reasons, is equally pressing, namely, the question of the disposal of sewage. The Reports of the Rugby Sewage Commission, and especially the elaborate and exhaustive Third Report, published in 1865, seem to leave no doubt upon this point; and it is satisfactory to find that the Pollution of Rivers Commission has adopted its suggestions, and has recommended the enforcement of sewage irrigation as the only way of preserving the purity of the streams. Many practical difficulties will no doubt have to be overcome, and some few doubts will still have to be cleared up, before this simple and rational method of utilizing sewage can be generally adopted; but enough has already been done to prove that success, in the great majority of cases at any rate, will be a matter of certainty. The Rivers Commissioners appear to have satisfied themselves upon one important point, and assert, in their Report on the River Thames (1866), "that no ground exists for serious apprehension of miasma from fields irrigated with sewage."*

If this process were generally and thoroughly applied, if the sewage were really passed through, and not merely over, the land, and the filtration, when necessary, repeated a second time, there would of course be a vast improvement in the quality of the river water. Land irrigation is by far the best mode of purifying sewage which is known, and is immeasurably superior to any method of precipitation. Precipitation, indeed, although it may, and often does, diminish the amount of organic matter present in solution in sewage, is rather a process of clarification than of absolute purification; whereas the action of grass-land is a chemical action, and, when properly applied, there can be no doubt that it affects a considerable alteration in the quality as well as quantity of the dissolved organic matter.† It will be seen that the urgent necessity for the adoption of this system raises a new question in regard to water-supply. It

* P. 12.

† Way, Evidence before Select Committee on Lea River Conservancy Bill, May, 1868.

may be asked whether, supposing the water of a river can be kept free from the contamination of all sewage except that which has been filtered through meadow land, it will be safe to use it for drinking purposes? An absolute answer cannot as yet be given to this question; but considering the large amount of organic matter which often remains in solution in such filtered sewage,* and the extreme risk of the filtration being in some cases imperfectly effected, it is highly improbable that water so contaminated could ever be used with safety. For the sake of the rivers, and for the sake of the land, the sewage must be purified; but it should not be forgotten that, after all its purification, it will still be sewage—the diluted and somewhat modified excreta of human beings—and as such will be disgusting, and possibly dangerous, as an article of food. Whether purified or not, the sewage, it is evident, must in most instances be discharged into the nearest river; and we are therefore led by this view of the case to the general inference that rivers, below the highest points at which they receive sewage, are unfit sources of water-supply.

But the subject of the sewage-contamination of water cannot be dismissed quite so easily as this. Very contrary opinions are held in regard to it; for although no one doubts that water largely contaminated with recent sewage is likely, or, rather, almost certain to lead to epidemic disease, many persons believe that, provided the admixture be small and that it has flowed for some miles down the stream, the well-known self-purifying power of the water, due to its dissolved oxygen, will have destroyed all organic bodies in it, and have rendered the sewage perfectly innocuous. This is the view held, very naturally, by the London water companies, and strenuously supported by Dr. Letheby, their consistent and zealous advocate. The question has been chiefly argued in relation to the cholera, and it will therefore be convenient to keep to that issue, although it must not be forgotten that sewage-polluted water is quite as deeply implicated as a cause of other forms of epidemic disease. Let any one who doubts this read the 'Report on Typhoid Fever at Tottenham,' by Dr. Seaton, and at Buglawton, by Dr. Buchanan. Both are printed in the Appendix to the Ninth Report of Mr. Simon, the medical officer of the Privy Council, 1867.

This last-named Report, together with the excellent 'Report on the Cholera Epidemic of 1866,' by Dr. Farr,† which forms the supplement to the Twenty-ninth Annual Report of the Registrar-General, afford ample materials for a consideration of this question, a consideration which is forced upon us by its close and intimate connection with our immediate subject. It is unnecessary to multiply proofs that water contaminated with choleraic discharges is a frequent

* 'Third Report of the Sewage Commission, 1865,' p 46.
† Published 1868.

cause of the disease. Some of the most striking were adduced by Dr. Frankland, in the admirable paper which he contributed to this Journal in July, 1867. To the cases there quoted may be added the frightful sporadic outbreak at Theydon Bois, in Essex, in the autumn of 1865, where nine persons out of a family of twelve, including servants and a visitor, died of the disease in a few days, and where it was distinctly proved that the first patient, and some of the others in turn, had from a defect in the sewage arrangements caused a contamination of the well-water.

The history of the epidemic in Newcastle in 1853, quoted by Dr. Farr, is not less instructive. But it must be understood that these numerous instances would be overstrained if we argued from them that choleraic water was the sole cause of cholera. Other causes, no doubt, are efficient in many cases for the propagation of the disease. Contact with cholera patients; the washing of their clothes; dust impregnated with choleraic discharges;* and the noxious emanations of sewer gases, have all been traced as causes in cases where water could not have been concerned. Dr. Macpherson† quotes the case of the Baltic fleet, in which distilled water only was used, and in which a violent epidemic took place; and in his lucid Report on Cholera in Southampton, in 1866,‡ Dr. Parkes exculpates the water-supply altogether, and succeeds in fixing the stigma upon the exhalations from a large volume of sewage which was being pumped through an open conduit at the time. This case is the more important, because the number of deaths reached a total of over 20 to 10,000 of the population, and because a similar cause is alleged by Mr. Orton as conducing to the epidemic in East London.

In all these dissimilar cases, however, there is one common circumstance to be noted, and to that the communication of the disease is almost invariably to be ascribed. The dejections of the sick, whether carried by air, water, or direct contact, have undoubtedly the power of infection; and the elaborate researches of the last few years have illustrated the cause of this power in a most remarkable manner. The zymotic theory of cholera—that theory which traces the origin of the disease to the presence and development in the intestinal canal of some peculiar form of organized matter—has for the last twenty years had many adherents, and the evidence of observation and experiment in support of it has increased materially of late, and has acquired a very high value. The subject is not one for a chemist to dwell upon, but it is impossible to avoid a slight reference to it here, as it lies at the root of the question of the safety of river water. Those

* Dr. Mudge, 'Med. Times and Gaz.,' May 18, 1867.
† 'Med. Times and Gaz.,' July 13, 1867.
‡ 'Ninth Report to Privy Council,' p. 244.

who require more detailed and trustworthy information may find abundance in Dr. Farr's Cholera Report, and also in Appendix No. 11 to Mr. Simon's Ninth Annual Report; both of which have been already quoted. The final conclusion of the best observers on the subject seems to be, that the active agent in cholera is to be found in certain "choleragenic molecules" (they receive different names by different writers), or germs of very low forms of life. These molecules are exceedingly minute—not more than $\frac{1}{25000}$th of an inch in diameter—and seem to be indistinguishable in appearance, though so very different in power, from the molecules of other zymotic diseases.* They are discharged in myriads in the flux of a cholera patient; and hence it probably is that this flux is the main agent in the conveyance of the disease. Dr. Farr proposes to call them "cholrads," and the choleraic matter containing them "cholrine." There is great convenience in the use of these terms, and for the future I shall adopt them. By careful experiments with this cholera matter Hallier succeeded in cultivating it in various artificial soils, and producing definite forms of fungoid growth. Dr. Thiersch, in 1854, and more conclusively, Dr. Burdon Sanderson, in 1866, made experiments on the action upon mice of papers steeped in cholera flux. Both found that a disease closely resembling cholera could be produced in this way; and these and other similar experiments seem to leave no doubt that this is the normal mode in which the infection is conveyed. What it is chiefly important to notice here is, that the specific poison of cholera is in all probability not a definite compound, like arsenic or strychnine, but a series of extremely minute solid particles, each of which, if placed in suitable conditions, may by fissiparity develop into an infinite number. The number which may be communicated to a river by the discharges of a single cholera patient can, of course, only be guessed at. One thousand millions of the cholrads would not occupy a larger space than a pin's head; and Dr. Farr gives a curious calculation, founded, for illustration, on the assumption that their number in the cholera flux is equal to that of the globules in the same volume of blood. According to this calculation, a single patient would introduce into the river no fewer than 41,769,000,000,000 of the cholrads. Now, the volume of the Thames at high water, from Bow Creek to Teddington, may be taken approximately as 14,000,000,000 gallons, and each gallon might, therefore, become contaminated with 2983 cholrads!† The

* Beale. To whose marvellously careful observations much of our knowledge on this subject is due.

† An error occurs in Dr. Farr's calculation, arising from the circumstance that Vierordt's estimate of the number of the blood-corpuscles is copied from the 6th edition of 'Carpenter's Physiology,' where it is incorrectly given as 5,069,000 per cubic *centimètre*, instead of per cubic millimètre. I have introduced the right figures in the text.

general properties of cholrine, as far as they have been ascertained, are well summed up by Dr. Farr. Its development is arrested by acids; and this, no doubt, accounts for the efficacy of sulphuric acid in premonitory diarrhœa, and affords a probable explanation of the apparently partial and occasional action of the poison. No doubt, certain favourable conditions of the body are necessary for the development of the germs, and these conditions may chance to be absent in any given number of cases. Dr. Frankland has found, as Chaveau found with vaccine granules, that cholrine cannot be separated from water by filtration—a fact which, from the exceeding minuteness of the cholrads, is not to be wondered at. Careful filtration, no doubt, removes very much of the noxious matter, the cholrads being probably entangled by the solid matters separated; but their complete separation would appear to be impossible. This most alarming fact is, however, to some extent, neutralized by the probability that a certain quantity of the poison is required to render its operation at all a matter of likelihood;* and by the further certainty that the germs cannot live for any great length of time in the water, unless recent fœcal matters are present; in which case, it is of course possible, that they may develop and reproduce themselves in the water, though no distinct evidence on this point has been obtained. Finally, a certain external temperature is necessary for the action of the poison; and when present in small quantity, it is absolutely impossible to detect it by chemical methods.

The whole history is unpleasant in the extreme; and the drinkers of sewage-contaminated water will be apt during warm weather to think more of the horrible possibility connected with their sparkling beverage, than even of any of the probabilities which its vendors may be able to allege in its defence. To take the case of the present water-supply of London. There can be no doubt that the sewage of thousands upon thousands of persons is thrown into it before it is collected by the companies. When cholera is prevalent, cholrine must be thrown in with this sewage, which at all times must contain the germs of some zymotic disease. Now it may be, and probably is in many cases, that the whole of the soluble organic matter is oxidized before it is consumed as drink; but who would like to trust to this probability? And even if the whole of the unorganized matter of the water were oxidized, there exists no security that the organized germs, the really mischievous part, would also be oxidized and rendered inert. Dr. Frankland points out,† that such germs would probably resist oxidation for a longer time than mere organic matter in solution. To quote his forcible illustration, an egg thrown whole

* Farr, *op. cit.*, xv.

† Frankland and Armstrong 'On the Analysis of Potable Waters,' Journal of the Chemical Society, March, 1868.

into the Thames at Oxford would probably retain its vitality at Teddington; but the same egg, if it had been broken and its contents beaten up in water, might have suffered complete oxidation in the same time.

Although, therefore, we may for the present be forced to remain contented with doing our utmost to secure the *minimum* of sewage-contamination in our water-supply, it is highly probable that in the future these makeshift precautions will not satisfy us. It behoves us of course to be extremely careful in deciding on radical changes in our water-supply; for although the case so far looks very black against sewage-contaminated water, the possibility must not be lost sight of, that it may ultimately break down altogether, and the London companies succeed in proving that no possible harm can arise under any circumstances from the use of their water.

The history of London water-supply and its connection with the cholera is a very important element in the inquiry to which we are thus impelled. Some points in it have been made the subjects of very fervent, if not acrimonious discussion, and to these points it is now necessary to allude as briefly as possible. The three last epidemics of cholera in London have found three different conditions of water-supply; and Dr. Farr has proved in the clearest manner that the progressive amelioration which has been effected in the quality of the water, has been accompanied by a corresponding diminution of the mortality of the disease. It is unnecessary to quote evidence on this point, because Dr. Frankland has given enough to convince any sane person, in his before-named article in this Journal. The fact is not indeed, as far as I am aware, doubted by any one. 'The Metropolis Water Act of 1852,' which prohibited the London companies, after the 31st August, 1865, from drawing their supply below the tidal points of the Thames and its tributaries, and compelled them to filter it, was undoubtedly the cause of the very slight virulence which marked the epidemic of 1866 in all the districts of London, with the important exception of those which were supplied from one reservoir belonging to the East London Water Company at Old Ford, Bow. We all know the terrible catastrophe that befel that fated region; we all read at the time, with lively sympathy and horror, the vivid narratives which week by week were compiled by Dr. Farr and the other investigators of the tragedy. The story need not here be told in detail. The acuteness of Dr. Farr soon suggested a probable cause for the localization of the outbreak; and Mr. Netten Radcliffe, who was specially commissioned by the Privy Council to inquire into the circumstance, and whose elaborate Report is printed as an Appendix in the Ninth Report of the Medical Officer, found himself compelled to adopt his hypothesis. It cannot now be doubted that the water of the ordinary reservoir at Old Ford was, on a particular

occasion, shortly before the outbreak in East London, contaminated with some unfiltered and probably foul water from one of two open reservoirs on the other side of the river Lea. Shortly before the probable date of this contamination (for the exact date cannot be fixed), the first two deaths from cholera in this district had occurred in Priory Street, Bromley, about 600 yards lower down the river. The open reservoirs were close to the river, which in this place is tidal, and the banks which divided them from it were almost certainly porous. It is therefore alleged that some portion of the poisonous discharges of the two Priory Street victims, which were undoubtedly thrown by the sewer into the Lea, found its way into the open reservoirs, and being from one of these admitted into the covered reservoir, carried its deadly infection throughout the whole district. Such is the result arrived at by Mr. Radcliffe from a variety of considerations, the chief of which may be taken to be the necessity of *some* definite cause having been at work to produce so peculiar and well-defined an effect. He establishes with great force the general localization of the epidemic in the sub-districts supplied with the water, and discusses *seriatim* all the causes which could be conceived to have occasioned this localization. Altitude, soil, density of population, filth, sewerage, and locality, are all considered in turn, and are all dismissed, either as not having been unfavourable, or as not having presented any marked differences from the condition of other places. By the application of this method of exclusion, he is led to the adoption of the water-theory which I have stated, and which has received the adhesion of Mr. Simon, as well as of Dr. Farr, who, in fact, originated it. He writes with singular moderation and impartiality, and has saved his opponents much trouble by the care with which he has pointed out the weak points of the theory.

It was, of course, not to be expected that views so damaging to vested interests should pass unchallenged; and a keen controversy has, in fact, been waged in regard to them, although the bulk of the medical profession has, I believe, accepted the conclusions of the Government officials. The most able collection of arguments that I have seen on the other side of the question is from the pen of Mr. Orton, the medical officer of health for the Limehouse district,* who has suggested some points which, as even Mr. Radcliffe admits, present grave difficulties. He argues that East London was in a very much worse condition than the rest of London in respect both of filth and of sewerage; and the picture which he draws of the sanitary condition of the neighbourhood is very striking, and is described with unusual power. The account of the Limekiln Dock Sewer, with its filthy windings, its syphons, or

* 'Report to the Board of Works for the Limehouse District for the year ending Lady-day, 1867.'

semicircular channels, intended for carrying sewage under canals, but serving, in addition, to collect and store up the more solid filth; its ventilating shafts and gully-gratings, and its final discharge into Limekiln Dock, is highly suggestive; and in reading the description, it is difficult to avoid the conclusion that so noxious a set of conditions must have contributed in some measure, at any rate, to the virulence of the explosion.

The high and middle levels of the northern drainage system unite at Old Ford, and the united torrent is carried on to Barking Creek. The unfinished low-level sewer, "choking with filth, from whatever source it came, probably from Poplar, took its course in this direction, right through the centre of the Limehouse district, on either side reeking with pestilence, into Ratcliffe Highway." My own local knowledge is not sufficient to enable me to decide upon the extent to which these various abominations may account for the sharp boundaries of the area of explosion; but Mr. Radcliffe, while admitting their probable influence, does not regard them as sufficient to account for the special phenomena observed. He remarks that East London was not peculiar in respect of unfinished sewerage works, for that all places on the line of the low-level sewer must have been in the same condition, and that the middle and high level sewers flowed through many places besides East London. But, on the other hand, it must be remembered that the mere circumstance of these places being situated higher up the line of the sewer, would, as Mr. Orton remarks, render them less likely to suffer injury from the sewage, the sewage being less in quantity, and probably less foul. Be this as it may, it cannot be doubted that the influence of filth on the course of the epidemic is deserving of careful inquiry, and this is freely admitted by Mr. Radcliffe himself.

Another formidable objection to the water-theory of the explosion is founded by Mr. Orton on the fact that certain places, and notably Stamford Hill and North Woolwich, which were continuously supplied from the Old Ford reservoir, did not suffer from cholera. The circumstance is highly remarkable; and Mr. Radcliffe is only able to explain it by showing the possibility that the infected water was really not distributed to the places in question until the day after the contamination, when the poison may be supposed to have become too dilute to be operative. Dr. Farr, however,* while noticing the fact that water was distributed to North Woolwich on the constant system, a circumstance that, by ensuring the main being full at the time of the contamination, would probably prevent the district from receiving the first portions of the contaminated water, suggests that in these remote districts the cholrine might

* 'Cholera Report,' xxvii.

well be supposed to have become precipitated, in virtue of its greater density, before the water was delivered. Mr. Radcliffe * makes the important admission that he holds the immunity of these places to be fatal to the idea that the water of the Old Ford reservoir was, during the epidemic, constantly and directly impregnated with choleraic poison by infiltration from the river Lea. If this be true, the case against the East London Company must rest entirely on the use, on one occasion, of water from the open reservoir; and the whole explosion must then be traced to the two deaths in Priory Street. I own I think this admission goes too far; for, looking to the whole circumstances of the epidemic, coupled with the history of other epidemics, I am constrained to admit the strong probability that the water-supply was implicated; and yet, on the other hand, I am unable to refer the whole explosion to the limited cause assigned by Mr. Radcliffe. My reasons for this rejection of Mr. Radcliffe's theory may be stated briefly.

The two deaths in Priory Street took place on the 27th of June, 1866. It appears probable that the contamination of the Old Ford reservoir occurred early in July, and the distribution of unfiltered water must therefore have followed the deaths in a few days' time. In the week ending July 14th the outbreak may be said to have commenced in East London; but the real force of it was not manifested until the following week, when the deaths suddenly rose to a most alarming extent. The following figures, taken from Table 21 in the Appendix to Dr. Farr's 'Cholera Report,' will serve to illustrate the progress of the epidemic. They refer solely to the East districts of London and the district of West Ham.

Week ending	Deaths from Cholera.
July 7, 1866	3
" 14, "	41
" 21, "	438
" 28, "	1002
Aug. 4, "	1046
" 11, "	664
" 18, "	341
" 25, "	169

An examination of these figures naturally suggests the inquiry, How many of these deaths can be supposed to have been the effect of cholrine discharged into the sewer on June 27th? Now, the experiments of Thiersch and Dr. Saunderson, already quoted, prove that cholrine, at any rate when dried on paper, is almost inert, when fresh, attains its *maximum* of activity on the third day, and is again inert by the sixth.

Probabilities are, therefore, against the idea that the discharges of the two Priory Street patients, could have acted as poison, unless

* 'Report,' p. 325.

they were actually drunk within six days afterwards, that is, before July 4th. Moreover, the period of incubation of the poison in the body is believed to be short. Dr. Farr says on this subject, "There is reason to believe that the period of incubation is as brief as the term of attack in fatal cases of cholera; the cholrine often acts as suddenly as any of the poisons."* And again, in another place, "It may now be laid down as an established law, that water into which cholera dejections find their way produces cases of cholera all over the district in which it is distributed for a certain period of time; and that if the distribution is in any way cut short, the deaths from cholera begin to decline within about three days of the date at which the distribution is stopped." †

Mr. Radcliffe, indeed, instances the outbreak at Theydon Bois, in order to show that the period of incubation may be somewhat longer than is here suggested, for in that instance several persons were attacked on the sixth day after the disuse of the water. If, however, we assume the utmost in every respect, and allow six days for the period during which the cholrine retained its activity in the water, seven days for the period of incubation, and three for the duration of the attack,‡ we are still compelled to admit that the Priory Street cases could only have led to those deaths which took place within sixteen days after the 27th of June, that is, at the outside, before the 14th of July. The above-quoted table shows us that only forty-four deaths occurred in this period, and it is difficult to imagine how the special contamination of the Old Ford reservoir can be made accountable for more than this number. If the view of the case be correct, the cause, or rather perhaps the causes, of this terrible mortality which followed are still to seek. Very probably the bad sanitary condition of the district aggravated the epidemic, and the mere establishment of the disease in a place is almost sure to lead to its increase by personal contact, the influence of impregnated soil, sewer gases, &c. But none of these, or even all of these combined, appear to me to account for the singularly well-marked and all-but universal prevalence of the disease in the districts supplied with the Old Ford water; and, in spite of some difficulties and apparent contradictions which beset the question, I find myself constantly led back to the belief that the Old Ford water must have contained cholrine. We can never know the exact truth of the matter, and must be contented to accept probabilities as our guide; and it appears to me much more probable that the Old Ford water should, either by infiltration from the Lea, or in some other manner, have become impregnated with cholera poison, than that the remarkable

* 'Cholera Report,' xxxiii. † Ibid., xxxix.

‡ About four-fifths of the deaths from cholera in England in 1866, excluding cases in which no return was made on the subject, took place within three days of the first attack, *vide* 'Cholera Report,' Table 12.

localization of the epidemic should have been entirely fortuitous. Dr. Letheby* has indeed suggested that the area affected coincides pretty nearly with that supplied with gas by the Commercial Gas Company, and that the gas might as well be accused as the water. But this ingenious special pleading will not bear a moment's examination; for not only is the coincidence between gas and water supply less perfect than is pretended, but bad water is well known as a very frequent cause of cholera; and it is absurd to suppose for a moment that gas has anything to do with it.

Most of the other evidence that is brought against the water theory of the epidemic of 1866, is founded on the immunity of individuals of certain houses or streets, and of some public building, where many persons were assembled during the epidemic, and which were supplied with water from Old Ford. The case of the Limehouse schools is perhaps the most striking instance of this kind. In this establishment nearly 400 pauper children lived in perfect health throughout the epidemic. Not a single case of cholera or even of epidemic diarrhœa occurred, although the children used the Old Ford water continuously. The sanitary arrangements are, indeed, described as excellent; every precaution that could be devised to prevent an outbreak of the disease was employed; and, instead of standing upon porous gravel, as the surrounding buildings do, the schools stand upon a thick bed of fine brick-earth, into which the soakage of sewage is impossible; but still the case is certainly curious, though it cannot be regarded as proving anything. The death-rate from cholera in Limehouse during the epidemic was 107·6 in 10,000; so that, if the average had been strictly preserved, four or five deaths would have occurred in the building. But uniformity cannot possibly be looked for in the distribution of an epidemic; and just as the mortality in some streets and houses was much above the average, so it must necessarily have been lower in others. No one thinks of supposing that water was the sole cause of the mortality; and it is not by any means wonderful that the well-fed and well-cared for inmates of a healthy building should have escaped the infection. The error lies with those who persist in assuming that the cholera poison is of the nature of arsenic or strychnine, and that it is therefore sure to produce the disease in every individual who takes it; the truth being, as we have before seen, that any given number of individuals may take cholrine into their stomachs without injury, and that they may even drink cholrine-contaminated water without getting any of the cholrine. A similar argument was brought forward by Dr. Letheby in respect to the London Hospital. In his evidence before the Select Committee of the House of Commons on East

* 'Evidence before Select Committee of House of Commons on East London Water Bills,' p. 429.

London Water Bills,* he stated that in the London Hospital, which is exclusively supplied with water from Old Ford, there was not, during the whole of the epidemic, one case of cholera among the ordinary inmates or attendants of the hospital. This statement, which is said to have been repeated before the Royal Commission on Water-supply, would, if correct, have supplied us with a still more curious instance than that of the Limehouse schools; but, unfortunately, it appears that Dr. Letheby's knowledge of his own hospital was inaccurate, for in the official hospital returns Mr. Bathurst Dove gives a detailed account of *seven* cases of cholera which occurred among the hospital attendants, and *one* among the ordinary patients. Six of these cases terminated fatally, including the patient, a child; so that, out of the 130 attendants employed in the hospital, five died—a proportion of 385 in 10,000!

It is now necessary to consider the amount and nature of the evidence which science is able to offer on the quality of water intended for drinking purposes. With respect to the mineral constituents of a sample of water, chemical analysis, of course, enables us to speak with great certainty and accuracy; and geology can, in most cases, account satisfactorily for the results of the analysis. It seldom happens, however, that a water which is used for drinking purposes contains any ingredient which, either from its nature or exorbitant amount, is likely to be deleterious to health. When calcium or magnesium salts are present in large quantity, they render the water inconveniently hard, and are therefore objectionable, as leading to an enormous waste of soap; but this is a subject which has been so fully discussed by Dr. Frankland in this Journal that it may now be passed over. Some of the mineral constituents which are found in ordinary waters, though entirely harmless in themselves, are yet of great significance, as throwing light on the previous history of the water. Thus ammonia and nitrous and nitric acids must be determined with the utmost care in the examination of a water, because, with the exception of a small and never-exceeded quantity which is derived from rain, they arise in the great majority of cases from the alteration of animal exuviæ in the water. So, again, with common salt and other chlorides. Though sometimes present naturally in waters uncontaminated with organic matter, any large quantity of them may generally be regarded as a sign that sewage contamination is present. For an analogous reason the gases dissolved in water yield valuable indications; oxygen being usually deficient and carbonic acid in excess when organic matter has undergone recent oxidation in the water. All these constituents can be estimated with the most astonishing accuracy even when present in extremely minute quantity, and it is from a

* 'Minutes of Evidence,' p. 45.

collation of these results that the previous history of the water is written. From the amount of nitrogen present, as ammonia and nitrates and nitrites, *minus* the quantity which may have been derived from aërial sources, Frankland calculates the "previous sewage-contamination" of the water on the assumption, founded on many analyses, that one part of nitrogen is contained in 10,000 parts of average London sewage. Of course, it must not be forgotten that this estimate includes previous *drainage* as well as previous sewage-contamination; for land drainage, especially in times of flood, carries to the rivers much of the soluble portions of the excreta of animals in a more or less complete state of decomposition; and it is obviously impossible to distinguish in a water the nitrogen which comes from sewage from the nitrogen which comes from drainage. But in spite of this drawback, the estimate of previous sewage-contamination in the London Companies' waters agrees so well with calculations founded on the number of persons whose sewage pollutes the streams, that it may, I believe, be accepted as a marvellously close approximation to the truth.

It is very much to be wished that we were able, by equally direct and accurate processes, to determine the quantity and nature of the "organic matter" which exists in solution in all polluted waters, except those in which natural oxidation has proceeded to its furthest limit. But, unfortunately, the very nature of the subject precludes us, and will perhaps for ever preclude us, from knowing much about the nature of this organic matter. For what is organic matter? It includes, according to the views of modern chemistry, all except the very simplest of carbon-containing compounds. The phrase is indeed only exceeded in vagueness by the idea for which it stands, and has been long discarded from the realm of pure science, in company with the "extractives" and "earthy matters" which formerly marked unknown regions on the map of science. To find organic matter in water is nothing. Sugar is organic matter, so is strychnine, and so is a worm, or the contents of an egg. In the complex wanderings which water often pursues in its journey from the clouds back to the sea, it is obviously liable to become contaminated with "organic matter" from the most various sources. It may pass through peat; through living plants or dead vegetation; through a paper-mill, a dye-house, or a soap-boiler's, or through all three; it may receive the washings of a pig-sty, the drainage of a town, or the garbage from a butcher's shop; and its composition will differ in every one of these cases. Moreover, if we knew exactly what contaminations the water had received, and their chemical nature, we should still be unable to say in what condition they existed in the water as we found it. For nearly all kinds of organic matter commence a complex series of changes from the moment they enter the water—a series which is only completed by

entire oxidation. These changes, no doubt, vary greatly with the nature of the organic matter, the amount of free oxygen which it meets with, the conditions of rest or agitation, the temperature, and so on. They belong to that most complex department of chemistry which deals with the processes of putrefaction, fermentation, and decay, and as such they are connected in some direct, but ill-understood manner, with the vital changes of low forms of organic life in the water. It is not wonderful that in such a chaos we should have to pick our way carefully, and should be compelled to decide rather by inference than direct proof, on the nature and significance of the organic contaminations in our river and well waters. The methods upon which reliance is placed vary from time to time as sounder views and wider knowledge are acquired, and they are still very imperfect, but enough has been done to justify great hopes in the future. It is unnecessary in this place to enter into the details of the recent improvements in analytical method, but some of their leading features must not pass unnoticed.

The old incineration process, in which organic matter is estimated by igniting the dried residue and noting the loss of weight, appears now to be pretty generally discredited. Its indications cannot, of course, furnish the least clue to the nature of the volatile matter, and do not even correctly record its amount; for even when all precautions are taken, some of the mineral substances, such as ammonia and nitrates, are sure to be volatilized, wholly or in part; and Frankland and Armstrong have, on the other hand, shown that urea, a very significant and important impurity, is not entirely volatilized during the process. To show the utter untrustworthiness of the method, it will be sufficient to mention that a water residue sometimes weighs more after ignition and treatment with carbonic acid than it did before. In such a case the analysis would, of course, indicate rather less than no organic matter!

The permanganate of potash process, suggested in the year 1850 by Forchhammer, has in the last few years been very largely employed, and has received many modifications of form. The permanganate, when applied in solution to the acidified water, loses a definite portion of its oxygen to the organic matter present; and the amount of oxygen so employed can be ascertained by the amount of the beautiful violet solution of the salt which is decolourized. Most chemists are content to record the amount of oxygen so indicated, or, at any rate, the amount of permanganate employed; but Dr. Letheby calculates the organic matter from the oxygen by multiplying its weight by eight. This would give a perfectly correct result, if all organic matter were equivalent to oxalic acid in its action on the permanganate. But this is so far from being the case, that it appears, from the careful experiments of Frankland and Armstrong, that of nine different kinds of organic matter

experimented upon, oxalic acid was the only one which was perfectly oxidized even in six hours. All the others escaped oxidation to a greater or less extent; and such important compounds as urea, creatin, and cane sugar, were scarcely oxidized at all. Moreover, although one part of oxygen will oxidize eight parts of oxalic acid, it could only oxidize perfectly 0·47 part of urea, 0·45 of creatin, or 0·89 of sugar; so that even if the oxidation effected by the permanganate were perfect, the calculation would be wrong. The consideration of the irregularity in the action of the permanganate test has induced Dr. Frankland and some other eminent chemists to abandon its use altogether; and in the present state of our knowledge this is perhaps the safest course to pursue; but I am by no means convinced that it may not, even yet, be made a most valuable auxiliary test in water analysis when properly used. In an interesting and suggestive pamphlet 'On the Examination of Water for Organic Matter,' by Dr. Angus Smith,* to whom we owe the earliest and some of the most successful attempts to discriminate between different kinds of organic matter in water, will be found many important details on the mode of using the test, and interpreting its results. I regret that space precludes me from quoting some of his results. I have derived much instruction from the perusal of the paper, and can only hope that the author will follow up his experiments, which appear to have been unavoidably postponed.

A new and very ingenious method of water analysis was presented to the Chemical Society of London on June 20, 1867, by Messrs. Wanklyn, Chapman, and Smith, and is more fully described in a little work published by the two first-named chemists in 1868.† The chief process is conducted in the following manner:—The quantity of ammonia in the water to be examined is first determined in the usual way by means of the Nessler test. Another portion is then mixed with carbonate of soda, and a fraction of it, usually about one-third, is distilled off, measured, and the ammonia it contains estimated as before. To the residue in the retort is now added an alkaline solution of permanganate of potash, and the liquid again distilled until a very small bulk remains. A third determination of ammonia is made in this distillate, and from these results three different portions of nitrogen are determined in the original water. The first portion exists in the water, as ammonia; the second is believed by the authors to exist as urea; and the third as albuminoid substances. If these distinctions were exact; if the whole of the nitrogen of urea could be recovered as ammonia in the first distillation, and the whole of the nitrogen of the albuminoid compounds in the second, this method would be, as far as it

* London: Taylor and Francis, 1868.

† 'Water Analysis: A Practical Treatise on the Examination of Potable Water.' London: Trübner and Co.

went, perfect; but, unfortunately, this is not the case. Pure urea does not yield the whole of its nitrogen under the circumstances of the experiment, and neither does pure albumen, unless with extreme difficulty. The authors believe that the ammonia obtained bears a definite and constant relation to the amount of those compounds present, and think themselves justified in calculating the amounts of urea and albuminoid compounds from the figures they obtain; but such a method is obviously inferior to one which should give more positive results. The process is very easy of application, and, as an empirical method of judging of the goodness or badness of a water it is certainly valuable. It gives concordant results; and though it is somewhat difficult to give a distinct interpretation of those results, without venturing on hypothetical ground, it may, I think, safely be used, when the more exact method of Frankland and Armstrong cannot be applied, as a means of judging whether a given sample of water is, or is not, fit for drinking purposes. Water which yields very minute traces of the so-called ureal and albuminoid ammonia, and is free from nitrates, can never, I believe, be injurious.

The process of Frankland and Armstrong, alluded to above, is described in their previously quoted paper, and is unquestionably the most important contribution to the study of potable water which has ever appeared. In this wonderfully exact and ingenious method, the dried residue of the water, which has been previously deprived of carbonic, nitric, and nitrous acids, by boiling with sulphurous acid, is ignited with chromate of lead in a combustion-tube sealed at one end, and connected at the other with a Sprengel-pump, by which a perfect vacuum is effected at the commencement of the experiment. During the ignition of the residue, the organic carbon is converted into carbonic anhydride, and the nitrogen is evolved either free or as nitric oxide. When the combustion is complete, the pump is again worked, and the gases formed during the experiment swept down by the falling mercury, and collected in an ordinary mercurial trough. They are then removed to another piece of apparatus, and measured and analyzed by known methods. Such, divested of details, is an outline of this remarkable process. It will be seen that no attempt is made by it to ascertain the absolute amount of organic matter present; but it furnishes us with precise information in regard to two of the most important elements of that organic matter, namely, the carbon and nitrogen. From the nitrogen found in the experiment must be deducted that present in the original water in the form of ammonia. A separate experiment must be made for this purpose, and a second for the determination of the nitrogen present, as nitrates, and nitrites, which yield their nitrogen in the form of nitric oxide when agitated with mercury and sulphuric acid. As the nitrogen, present as nitrates, nitrites, and ammonia, are used as a measure of previous sewage-contamina-

tion, so the organic nitrogen may be made an index to the *present* sewage-contamination, on the same assumption as before, namely, that one part of nitrogen corresponds to 10,000 of sewage.

With regard to the presence of organized germs, such as cholrads in the water, their chemical composition would probably approximate to that of albumen; but their minute size, as it has hitherto rendered it impossible to detect them in water by the microscope, so it serves to place them beyond the reach of chemical methods. Even if we could distinctly prove the presence of albuminoid compounds in a sample of water, it would, on chemical evidence, be impossible to say whether or not it was organized. It might consist of white of egg, or it might consist of cholrads, for anything that an analysis could show. The only safeguard which can be adopted against the presence of noxious germs in our drinking-water is, as I have already said, the complete exclusion of all sewage from sources of the supply.

Although the microscope has hitherto failed to detect in water the germs of zymotic disease, it must not be supposed that its indications are of no value in the diagnosis. When Dr. Hassall was preparing his Report to the Committee, which, in 1854, was commissioned by the Medical Council of the General Board of Health to make scientific inquiries in relation to the cholera epidemic of that year, he observed and described a great many low forms of life in the waters consumed in London. Some of the animal forms are terrible-looking monsters, and the coloured drawings in which they are portrayed are by no means pleasant to contemplate.* But Dr. Hassall states explicitly that none of these tiny monsters can be identified in any way with the cholera, for all of them are found frequently when cholera is absent. In like manner he found vibrions in myriads in "every drop of every sample" of the rice-water discharges of cholera patients which he examined; but knowing the ease with which vibrions are developed under a variety of circumstances, he did not venture to connect them in a causal relation with the disease. But we must remember that animalculæ are formed of albuminoid compounds, and that if their germs develop in the water, it is a certain proof that the nourishment necessary for their subsistence is present. In pure water it is impossible for organic life to be developed; and the presence of such life may therefore be taken as a certain proof of nitrogenous and therefore probably of sewage contamination. In fact, I cannot help agreeing with Dr. Angus Smith, in the belief that the microscope is too much neglected in examinations of water.

The length to which this article has already extended has left me but little space for a consideration of the various projects for the amelioration of the water-supply of London which are now before

* *See, for example, Plates 5, 10, and 12, in Appendix to Report.*

the public. I regret this the less, because it would be premature to express a decided opinion on their respective merits until the appearance of the Report of the Royal Commission on Water-supply. It would indeed be folly to attempt the work of criticism in anticipation of the full particulars which that document will no doubt supply on each of the separate projects; but a slight sketch of their leading characteristics may, perhaps, be found useful. The schemes may be divided generally into those which propose to confine the source of supply to the Thames basin, and those which propose to take the supply from a distance. There is, indeed, one scheme—that of Mr. A. S. Ormsby*—which belongs to neither of these classes. He proposes to collect rain-water by means of vast roofs of glass and iron, so arranged that the water may immediately flow off into receiving, and hence into settling, filtering, storage, and distributing reservoirs. These might be constructed either in the immediate neighbourhood of London or on Salisbury Plain, where, by roofing in a space of 2012 acres, a supply might be obtained that would, the author estimates, supply one gallon of pure water per head per diem to the inhabitants of London. The ground below the roofs might be employed by market, fruit, and flower gardeners. The supply would, of course, be only supplementary to the ordinary supply; and we should, therefore, be provided with water of two qualities—one for drinking, and one for all other purposes. Such a double supply would, I imagine, be a grave objection to the scheme; and I do not think it very likely to find favour in London, though it might probably, as the author suggests, be used advantageously in some of our foreign stations where water is scarce or of bad quality.

Apart from Mr. Ormsby's, the projects stand as follows:—

Thames Basin Supply.—Mr. Bailey Denton,† Mr. Telford Macneill.‡

North Wales.—Mr. Bateman.§

South Wales.—Mr. Fulton.‖

Cumberland and Westmoreland.—Messrs. Hemans and Hassard.¶

Staffordshire and Derbyshire Hills.—Mr. Remington.**

It is obvious at the first glance that those schemes which propose to utilize the Thames basin have a great initial advantage. The strongest reasons ought to be shown to induce us to quit our natural watershed for a distant one, for the objections to such a

* 'A New Idea for the Water-supply of Towns.' Metchim & Son, Parliament Street. 1867.

† 'The Water Question: A Letter to the Earl of Derby.' London: Stanford, 1866.

‡ 'Water-supply of London by means of Natural Filtration of the Water of the River Thames.' London: Stanford, 1866.

§ 'Sources of the River Severn.' London: Vacher, 1865.

‖ Mr. Fulton has favoured me with a description of his scheme in manuscript.

¶ 'On the Future Water-supply of London.' London: Stanford, 1866.

** 'Engineering.'

change are manifold. In the first place there is the very important question of expense; and it needs no great consideration to perceive the probability that the farther we go from home the more we shall have to pay for the journey. Then, again, we have to look at the extent of the source of supply; for in a work of such magnitude it would be absurd to adopt a scheme which did not provide for a very great extension with the increase of population. The supply to be obtained from the Thames basin is practically unlimited, the enormous surface more than atoning for the rainfall being less than in mountainous districts. During the long drought of last summer the supply of water to the metropolis never fell short for a single day; and the London companies have reason with them when they point to the terrible scarcity that was experienced in many parts of the island, and, amongst others, in Manchester, during the prevalence of the dry weather. All the gathering grounds proposed for London are petty in comparison with the enormous basin of the Thames; and to be secure from the possibility of a short supply, reservoirs of vast size for the storage of storm-water would have to be provided. And, finally, it has been urged with great force that we are not justified, except in case of actual necessity, in withdrawing from the Midland Counties the supply which sooner or later may become of extreme importance to them.

Armed with arguments such as these come the proposals of Mr. Bailey Denton and Mr. Telford Macneill. I cannot, of course, follow the engineering details of these or any other of the schemes, and, indeed, feel considerable diffidence in describing them at all. In Mr. Denton's interesting letter it is suggested that, whereas it is impossible to prevent the fouling of rivers by sewage, a line ought to be fixed on each river above which its freedom from sewage-contamination shall be jealously preserved. To ensure a sufficient supply for London in the face of these precautions, storage reservoirs for the collection of the surplus water of floods must be provided, and an increase effected in the volume of the rivers by means of an efficient system of drainage. Such a system would, no doubt, supply us with *sewage*-free water; but it must be remembered that a great portion of the water would still be *drainage* water, arising in great part from cultivated land. It is perhaps rather less unpleasant to drink the exuviæ of cattle, sheep, and pigs, than that of human beings; but it must be distinctly understood that that is the only improvement suggested.

Mr. Telford Macneill proposes to draw the Thames water from the river at Teddington, and carry it back by an open canal to the Bagshot sands, where it would be subjected to a process of natural filtration, and would then be conducted by a covered conduit to a service reservoir at Norwood. He calculates that, with the addition of a certain quantity to be collected from the Guildford district, a

supply of 400 million gallons per day of pure water could be provided in this manner, and that the supply so obtained would have the great advantage of being always cool. I cannot pretend to give an opinion on the merits of this scheme, which rest almost entirely on engineering questions. As to the question, whether such a gigantic filtration would be certain to remove all noxious matters from the water, that . a point which could not be decided off-hand.

Out of the four schemes which propose to draw the London water-supply from distant collecting-grounds, two (those of Mr. Bateman, and Messrs. Hemans and Hassard) have already been noticed in these pages. Mr. Bateman, it will be remembered, proposes to go to the sources of the Severn, and store up the water of the North Wales mountains in enormous reservoirs; while Messrs. Hemans and Hassard would impound and increase, by intercepting conduits, the waters of lakes Haweswater, Ullswater, and Thirlmere. Mr. Remington's scheme I am but imperfectly acquainted with, but Mr. Fulton's deserves a word of notice. He has selected, in the basin of the river Wye, in South Wales, a larger collecting-ground than either of the above-mentioned ones. He divides the gathering ground into four districts, having a total area of 440 square miles; the whole capable, he estimates, of supplying London with 393 million gallons per diem; but he proposes, in the first instance, to utilize only one of these districts, and to content himself with a daily supply of 130 million gallons. To guard against deficiency of supply, he proposes to construct impounding reservoirs in each district, capable of containing 150 days' supply. The water is to be conducted by a conduit, which shall pass near Bromsgrove, Warwick, Banbury, and Watford, to Totteridge, near Barnet, where service reservoirs will be constructed. The conduit will be 180 miles in length. The cost for a supply of 130 million gallons a-day, the conduit being large enough for 230, is estimated at 7,000,000*l*. The great merit of the scheme appears to me to lie in the thin population of the Wye basin and the absence of large towns on the line of the proposed conduit, which might claim a prior right to the gathering grounds.

With this meagre sketch of the present claimants for the honour of supplying London I must conclude. To the report of the Royal Commission we must now look for further light on the subject, with the hope that their labours will result in securing to London that priceless treasure—an unimpeachable and abundant water-supply. That is the object to be striven for; and the richest city in the world will surely allow no paltry motives of economy to prevent the attainment of that which is so essential to the health and well-being of her children.

CHRONICLES OF SCIENCE,

Including the Proceedings of Learned Societies at Home and Abroad; and Notices of Recent Scientific Literature.

1. AGRICULTURE.

THE past quarter has been full of agricultural interest. Thanks to the Chambers of Agriculture throughout the country, and their central representative in London, farmers are gradually acquiring that share in the conduct of public affairs which properly belongs to their wealth, their numbers, and their importance. As every addition to power and self-respect quickly shows itself in material results, it is proper that a social development of this kind be noticed here. And though for the present the movement bears rather a political than a practical aspect, yet we shall, no doubt, soon find technical and professional advancement marching in equal step with political and social progress.

Turning now to the details of agricultural experience, we have to report that the severe drought of 1868, which resulted in the utter failure of the turnip crop, the complete stoppage for several months of all grass growth, and the provision of but a scanty crop of hay for winter use, has been followed by so mild and wet a winter that autumn-sown green crops (stubble turnips, rye, rape, mustard, and Italian rye-grass) have done much to meet the difficulties which the stock-owner had anticipated. And the smaller consumption of succulent food, and the larger use of straw cut into chaff, and mixed with meal or cake for cattle and sheep (whether in a fatting or ordinary "store," or a breeding condition), have at once kept the live-stock of the country in a more than usually healthy condition, and proved a useful lesson of economy for future seasons. An inquiry into the agricultural lessons of so unusual a season has shown that land-drainage is serviceable even in a drought—both directly by deepening and enlarging the storehouse of vegetable resource on which plants can draw, and indirectly by enabling a deeper, earlier, and more thorough tillage, which hinders the cracking of the surface, and thus the searching influence of dry weather.

It has also shown the advantage in farm practice of retaining for use seed-beds of plants, such as cabbages, capable of transplanting as soon as rain comes, and thus of furnishing the earliest possible provision against a scarcity consequent on the failure of ordinary crops. It has shown, too, the great injury done to farmers,

and to agriculture generally, by a rigid system of rules laid down in agreements between landlord and tenant. Those who felt at liberty, whether as to the subsequent cropping of the land in consequence of a failure of the young clover plant, or as to immediate cropping to make up for a deficient mangold and turnip crop, to act as they thought best under the unusual circumstances, have been much better off than those who could do nothing out of the rule of rotation laid down to them without special licence from the owner or the agent.

The dry weather was a great aid to those who are interested in the promotion of sewage farming.

At the recent annual meeting of the Liverpool Sewage Utilization Company, Mr. R. Neilson, the chairman, gave some information as to the satisfactory progress of the company's works. The original intention of laying the main line to the Crosby Sands was prevented by obstacles over which the company had no control. They had consequently arranged with Mr. Blundell, of Ince, for a lease of 40 acres of excellent land, on which to develop the system, and advantageously supply the sewage to a number of the tenants of that gentleman and of Lord Sefton, who were anxious to take it. Seven and a-half miles had already been laid. The erection of the buildings of the pumping station was completed, the boilers were in their places, and the principal portion of the engines were already finished. The connecting sewer had also been completed from the well to the point of junction with the main sewer which received the sewage from all the upper parts of Liverpool and Everton, as far as Edge Hill, being that portion of the town where water-closets had been most generally adopted, and which would give a comparatively inexhaustible supply.

On Lodge Farm, situated near the market gardens around Barking, which were dried up and comparatively unproductive, enormous growths of cabbages, mangold-wurzel, and other succulent crops were obtained by three or four soakings with sewage in the course of the year; and unusual success also attended the use of sewage even for corn crops. A return of potatoes, grown with sewage, was obtained, equal to 50*l.* an acre: cabbages, sold for 20*l.* an acre, and stubble turnips, sold for 11*l.* an acre, were grown during the autumn months. Five and a-half quarters of wheat, taken after the wheat crop of 1867, on poor gravelly soil, were obtained by the use of two dressings of sewage; and heavy crops of rye and winter oats were also grown. Around Salisbury, and in other water-meadow districts, the value of summer irrigation was seen, and farmers who owned any water-meadow had an immense advantage over their burned-up neighbours.

As another feature of the season, we have to mention the successful commencement of the sugar-beet cultivation in this country.

Analyses have proved that our sugar-beets of 1868 have contained 9 per cent. of sugar, which is rather more than those of Dutch growth: and roots grown with sewage at Lodge Farm yielded over 13 per cent. to Dr. Voelcker. Mr. Duncan's factory at Lavenham has begun work. Eight hundred tons have been grown for him by the Suffolk farmers; and contracts have been completed to supply six thousand tons next year; and there is every prospect of the industry being established at other points. At a recent meeting of the West Suffolk Chamber of Agriculture, Mr. Duncan said that the prospect of a satisfactory establishment of the beet-sugar manufacture in England now is greater than it has ever been, for in Cuba—which alone has hitherto supplied us with as much sugar as all the beet-sugar of the Continent—the abandonment of slavery is imminent; and this will, no doubt, so diminish supplies as very materially to raise the price. Moreover, the industry is not by any means an exhaustion of the soil. Sugar-beet does not exhaust the land, even so much as mangold-wurzel growing. A small root, with a small percentage of ash is desired: and as it is the ash alone which the plant takes from the soil, that will for the most part be returned to it in the compressed cake of pulp which is sent back from the factory to the farm.

Turning now to another subject, we find from Dr. Voelcker's report to the English Agricultural Society, that four hundred and thirty-two analyses of manures, and cattle food, made in 1868, indicate the general excellence of the superphosphates supplied to English farmers last year. Compound artificial manures, on the other hand, which are generally manufactured on a basis of spoiled guano, were inferior and dear. Sulphate of ammonia has increased in use for other purposes than those of English agriculture, and has thus risen enormously in value. The coprolite beds of Suffolk and Cambridgeshire are gradually becoming exhausted. Large quantities of Sombrero rock, and of the recently discovered phosphorite of the valley of the Lalm, in Nassau, have been imported.

The immense demand for artificial foods has given a greater impetus to the adulteration of oilcakes. Among other newly introduced cattle foods is "Nutritious cocoa extract." "Theobroma," the generic name of the plant, signifying "food for gods," has long since proved an agreeable food for man, and it is quite possible that some of the coarser refuse part of the seeds from which the cocoa of the breakfast table is obtained may yield a wholesome food for beasts.

Among the more important points in Dr. Voelcker's report is the scarcity of sulphate of ammonia. M. Ville, of Paris, has lately made known the fact that salts of ammonia are found in large quantities in some of the Tuscan lagoons. This fact had, indeed, been already fully investigated and published by M. Becchi, a distinguished Italian chemist and mineralogist, who in 1853 described a

mineral known as "Larderelliti," named after the proprietor of the estate, and containing a considerable percentage of ammonia. A large block of this mineral, which is a borate of ammonia, was shown in the International Exhibition of 1862. Since then M. Becchi has continued his researches, and obtained by the recrystallization of the residual salts left when some water from a lagoon at Travale was evaporated, a sample of ammoniacal mineral, containing no less than 80 per cent. of the pure salt. The announcement of such a fact as this is a very important point in the recent history of agriculture; and, though an Italian discovery, it will very soon tell upon English fertility.

Coming home again, we have to report the activity of our local farmers' clubs, on whose operations, as well as on imported fertilizers, English fertility very materially hinges. The subjects of deep cultivation, steam culture, live-stock management, dairy farming, the increase of home-meat production, the condition of the labourer, the serviceableness of benefit societies on his behalf, the best way of dealing with pauperism, the relations of railways and agriculture, have been thus discussed. And it is not only the strictly Agricultural Society which thus benefits the farmer. The Society of Arts has interested itself in, among other agricultural topics, the provision of contrivances for the safe transit of milk and meat by railway. And, in competition for its prizes, some thirty or forty devices have been exhibited, more or less simple and efficient, out of which, probably, some improvement may arise in the present very imperfect arrangements by which so large a proportion of the food of the metropolis now reaches the consumer.

From the annual returns of the Board of Trade, giving the agricultural statistics of the years 1867 and 1868, it appears that a considerable increase took place last year in the area under wheat, and a diminution under all other grain crops. There was an increase in the area of the potato crop, and a diminution under all other green crops. An increase in the number of cattle and sheep was returned, and a diminution in the number of pigs.

2. ARCHÆOLOGY (Pre-Historic),

And Notices of Recent Archæological Works.

Mr. G. V. Du Noyer, late of the Geological Survey of Ireland (whose death we regret to record), communicated a paper last year to the Geological Society,* "On Flint Flakes from Carrickfergus and Larne." These worked flints (a series of which is placed in the

* Which appears first in the list of postponed papers published in the February number of the Society's Journal, p. 48.

Museum of Practical Geology, Jermyn Street) were picked up by the author from the gravelly drift and subsoil clay of the north of Ireland, in Antrim and Down. Mr. Du Noyer describes the method of forming the flakes, and points out that they appear to belong to two different periods, *viz*:—1. In the drift-sand and gravel which skirt the shores of Belfast and Larne Loughs, in the Co. Antrim, and the coast from Holywood to Donaghadee in the Co. Down, about 20 feet above high-water mark. These are rude in form and are always oxidized on the surface, and are often much abraded. 2. In the subsoil clay at all elevations up to 600 feet or so, on the northern slopes of Cave Hill at Belfast, the Common of Carrickfergus and the high-ground around Larne Lough, and the Island Magee, they often occur in groups so that hundreds can be collected over a surface of fifty square yards, and their appearance is fresher than the littoral specimens. In Island Magee they would appear to have manufactured some, judging by the hoards found. Mr. Du Noyer considered that the great abundance of flint-implements in this region was due to the aborigines seeking the natural outcrop of the chalk to obtain the raw material; he further suggests that the leaf-shaped flint-flakes of this second epoch (found in the bed of the river Bunn) were known and used by the earliest of the historic races in Ireland, and by them worked into those delicately-chipped and symmetrically-formed winged arrow-heads, spear and javelin heads which are found so often, associated with rude pottery, beads of amber, glass, and shells, in the sepulchral tumuli and megalithic chambers of Ireland.

In Mr. Bauerman's paper on Arabia Petræa,* he gives an account of the ancient Turquoise-workings in the Wady Maghara, which, although much encumbered by cliff-falls at the outside, are for the most part accessible for a considerable distance from the surface, and in many instances the old faces of work can be seen. These are covered with small and irregular tool-marks, of such a character as to leave no doubt that they have been made with flint-flakes, great numbers of which are found strewing the valleys and hill-sides, as well as within the workings themselves. Most of these flakes are of a triangular or trapeziform section, brought up to a point, which is generally well-worn and rounded, and the shape of which, when blunted, corresponds perfectly with the grooves on the face of the rock. In one of the smaller caves, carefully examined by Mr. J. K. Lord, the floor was covered to a considerable depth with a coating of impalpable dust, which, when disturbed, rose in suffocating clouds. On sifting this, numerous fragments of stone hammers and pieces of wood, some partially carbonized, but which had evidently been fashioned into tools, were found.

* Also in the February number of the 'Quart. Journ. Geol. Soc.'

The latter form segments of cylindrical blocks, with roughly conical points (that have evidently been shaped with a blunt, or imperfectly cutting tool), with a thickened head, notched round underneath as if to receive a withe or cord. The head bears evident marks of having been subjected to repeated blows. Although only a single segment in any degree of perfection was found, there can be little doubt that these were used as mountings for the flint chisels employed by the ancient miners. Without something of the kind it would be difficult to work with the flakes, owing to their tendency to break across when not struck fairly on the top.*

The hammers found in the workings were mostly of a very rude kind; in many cases rough natural fragments of dolerite, taken from the flow capping the adjacent hills, have been used, only a pair of holes on opposite sides, produced by the action of sand pressed upon the surface by the thumb and forefinger, being apparent. Some, however, show a little more work, having a groove, to receive a withe handle, cut round them, like the so-called Aztec hammers found in the aboriginal workings in the Lake Superior Copper Mines. Most of them are broken at the ends, and can only be regarded as spoiled or waste tools. The same holds good with regard to the wooden fragments and flint-flakes. Tablets cut on the face of the rock show these workings to have extended from the 3rd to the 13th Manethonian dynasties, corresponding to an interval of about 1600 years.

Captain F. von Koschkull, writing on the Caucasus,† mentions that, being engaged in a survey of the Salt-district in 1865, he had his attention attracted by some old mines which were regarded by the inhabitants as natural caves. (The principal beds of rock-salt, we should state, are in the valley of the Araxis, both east and west of Mount Ararat, and geologically are of Lower Tertiary age.) Captain Koschkull soon satisfied himself of their being the work of man, and resolved to explore them. At first his guides would fain have dissuaded him from carrying the plan into execution, as their imagination had peopled all these subterranean passages with evil spirits, of which they stood in bodily fear. Disregarding their superstitions, the Captain penetrated one of the ancient adits, and partially explored what proved to be a very extensive and fairly-well-wrought mine, evidently of great antiquity. At the remote end of one of the galleries he found heaps of mined salt, and hundreds of tools of various forms and sizes, either perfect, or more or less worn and broken. These implements consisted for the most

* A gentleman present when this paper was read (we think Dr. Murie), suggested that it was more probably a tent-peg, such as the Arabs use for driving into the ground to secure the border of the tent.

† Silliman's American 'Journal of Science and Art,' vol. xlvi., p. 336.

part of picks or pick and hammer combined, and varying from 5 to 15 inches in length, wrought with great labour and considerable skill out of a tough hornblendic rock. None of these tools were pierced for the insertion of handles, but all were encircled by grooves for the reception of withes or thongs; in this, as in the character of the material of which they were formed, resembling many of the stone implements of Europe, and being apparently the product of the same age, or more accurately speaking, of the same stage of intellectual development. The same author mentions that in the mountains of Karthli-Imeritia are excavated ("troglodyte") houses, and an entire city has been discovered, wrought out of the rocky walls which border the narrow valley of the river Ljokhwa, an affluent of the Kur. He was also present and assisted (in 1864) at the opening of two royal tombs which had been found in one of two tumuli, called the twin tumuli, situated upon the peninsula of Taman. They proved to be of Greek origin, and contained two sarcophagi of cypress wood, carved and gilded. The contents of the sepulchral vault were very rich and varied, and belonged to a period of high art and civilization.

Early in September last, in making excavations for a sewer at Trowse, near Norwich, a number of oak piles were discovered by the workmen, driven into a bed of compact river-gravel, 7 feet beneath the surface, and covered by 3 feet of peat, containing fresh-water shells and abundance of bones; but no flint or other implements were met with. The evidence is too scanty to form any positive conclusion upon; but in this broad but shallow valley, before the peat accumulated, it is suggested the piles stood in the water, and formed the base of a pile-work habitation, from which the large quantity of bones were thrown into the water. The animals identified were sheep, horse, deer; so plentiful were the bones that the navvies sold them by bushels to the dealers. Owing to the nature of the contract, the trench was again refilled within forty-eight hours from the discovery being made, and so all further search was stopped. If the site of a habitation, it must have been at a *comparatively late period.*

In the 'Journal of the Proceedings of the Essex Institute,'* Salem, Massachusetts, Mr. F. W. Putnam gave an account of the exploration of several Indian shell-banks at Goose Island, in Casco Bay, and at Ipswich. Many relics were found of great interest to the archæologist.

He also exhibited a series of Indian stone implements, found in Essex county, consisting of axes, tomahawks, gouges, arrow-heads, and many others to which no accurate name could be given. Some he considered were "sinkers," from their being found on the shore

* Vol. v., No. viii. Dec., 1868.

at Swampscott, and other places, and they seemed from their form well adapted for sinking a fish-net.

There were several stones of a flattened oval form, and others nearly round, all having a groove cut round them: also some flat, smooth stones, with two holes bored through them, perhaps used in the process of rope-making to twist strips of skin or bark together. Besides these were some stones of very perfect finish and of various shapes, but all provided with a hole through the thickest part; in blowing into which (as one does into a key) a loud call or whistle could be sounded. Mr. C. Cooke gives a description of an Indian burying-place in Essex county, containing six skeletons, lying from 18 inches to 2 feet beneath the surface, and placed in a row north and south, 5 feet apart, save two, which were within 18 inches of one another. Beneath each skeleton were placed three flat pieces of red sandstone—a rock not found in this region—one piece beneath the head, another near the middle of the body, and the third under the feet. All the skeletons were in the same position; namely, lying on their left side, with their faces turned to the west, the hands under the head, and the knees drawn up against the chest.

M. Roulin laid before the Academy of Sciences* a report on a series of stone implements from Java, collected and forwarded, by M. Van de Poel, of Cheribon, as a present to the French Government. The collection comprises thirty-nine articles of polished stone, which were successively dug up from great depths in the soil. They belong to a period antecedent to all the records and traditions of the country. It is difficult to obtain any from the natives, owing to the adoration they profess for them. The specimens differ in general aspect from any already in the possession of the Academy; they are remarkable for the beauty of the materials out of which they have been shaped, and for the symmetry of their form. They vary in size from 385 millimètres in length to only 26 millimètres; these being the two extreme measurements. Owing to the want of any information relating to the mode of occurrence of the specimens, the report is confined to their direct examination, and the comparison of them with analogous modern objects. Nearly all of them belong to implements of labour; there are, besides, three bracelets and a thin plate of oval shape, probably "*destiné à une incrustation*," which from their style of workmanship are evidently to be associated with the other specimens. There is a very striking absence of all kind of arms. It is impossible to suppose that the ancient Javans were entirely wanting in weapons of warfare or of the chase; but perhaps these were made of wood, like those now used over a large portion of Polynesia. Under ordinary circumstances it does not require many years to efface the

* 'Comptes Rendus de l'Acad. des Sciences.' Paris, 28 Dec., 1868.

traces of such arms. Still, some vestiges would have escaped destruction, and they will, when discovered, become the objects of much interest. Fifteen only of the thirty-five implements are entire, but some of the others, though not perfect, are of great importance. One of these latter, made of a greyish flint, formed part of a strong blade 25 millimètres in thickness, smooth beneath, slightly convex above, of a uniform width and thickness (82 and 25 millimètres respectively). Its length, which at first must have been—so far as we can judge by its other dimensions—from 12 to 15 centimètres, is no more than 8; in this state it was still large enough to be made useful, and by the following expedient:—It was necessary to make a new edge, and it was first cut square. This was performed by two saw-cuts made on the opposite faces, and continued so as to nearly meet, the separation having, however, been finished by fracture. The stone appears to have been attacked first on the convex side, which is more deeply cut, and, strange to say, the depth of the notch is likewise convex. This cutting or sawing may have been performed in a manner similar to that practised by the inhabitants of St. Domingo, and their neighbours on the adjoining continent, as recorded by Oviedo, who visited the country in 1513. With sand and a thread of *cabuia* or *henequen* (two species of agave) they can cut iron. They make use of the thread as we should of a saw, drawing it alternately from right to left, during which they move about and rub quickly against the iron very fine sand, which they have previously spread along the passage. Some of the other specimens have been cut in a similar manner. In the majority of the Javan specimens the edges are square, and the thickness nearly uniform—features that are characteristic of the Scandinavian celts. The implements seem all adapted for cutting wood. Some of the heavier specimens must have needed both the arms of a strong man to wield them, and they probably were used for chopping down trees, whilst the smaller tools, which could be used with one arm, were intended for more delicate work. All have been shaped on a similar plan. They offer in general a single cutting-edge formed at the expense of the lower face, which is even, or slightly concave, like our modern adzes. They have been formed from flint, chalcedony, jasper, porphyry, aphanite, sandstone, &c. The report is illustrated with a plate, representing an adze from the Isle D'Oualan (Carolinas), and an ancient implement found in Egypt, which are very similar to the forms from Java, described by M. Roulin.

Mr. Woodward read a paper before the Geologists' Association on "Man and the Mammoth; being an Account of the Animals found associated with early Man in Pre-historic Times."* The

* The lecture has since been published *in extenso* in the 'Geological Magazine,' February, 1869, p. 58.

author gave an account of cavern-explorations and their results; the progress of discovery in the Quaternary deposits; the proposed order of chronological sequence of the various remains found in river-gravels, peat-mosses, kitchen-middens, caves, crannoges, *pfahlbauten*, &c.; of the animals found, whether migrated, extinct, now living, or having been killed off by the hand of man.

He pointed out that widely different states of civilization (as at the present day) might then have existed in close proximity to each other, and suggested that the old cave-dwellers of Perigord represented the population of the less civilized portion of the globe, as the aborigines of Africa, America, and Australia do now in our own day.

Ethnological Society.

The Ethnological Society have resolved to institute a permanent committee (upon a scheme proposed by Col. Lane Fox, Hon. Sec.), for the purpose of examining into the validity of all evidence submitted to the Society, or otherwise obtainable, in relation to the science of man. To assess the relative value of such evidence, whether direct or second-hand, and to record the names of the authors or communicators according to a scale to be hereafter determined upon. To decide on a fixed terminology, and to classify all facts admitted in evidence. The classification to include the following primary divisions:—1, Races; 2, Languages; 3, Religions; 4, Folk Lore and Superstitions; 5, Laws, Customs, and Institutions; 6, Works of Art and Industry.

Another part of the scheme is the distribution of skeleton maps of various sizes for the purpose of marking the geographical distribution of the several classes. Distributions arranged by individual members will be discussed by the Committee, who will from time to time report to the Society the progress they make. Registers will be kept which shall be available to any member of the Society desiring to consult them. Such a scheme, if carried out successfully, is likely to result in a rich harvest of materials on which, at a future day, sound generalizations may be based.

Anthropological Society of London.

A paper was read on the 2nd of February, by the Rev. J. G. Atkinson, on the "Cleveland Gravehills." The moorland districts of the valley of the Esk, lying to the west of Whitby, at between eight and sixteen miles distance, are thickly studded with burial mounds or barrows, or in the old Danish vernacular, "howes." Many have been destroyed; but of the larger ones which remain, a large proportion have been examined by the author.

obtained forty-five urns and evidence of more than one hundred interments after cremation, but not any trace of metal. In some of the larger mounds, evidence appeared of three successive interments: first, in the centre; the second, inserted at a distance from the centre, and rudely and violently misplaced to make room for a third, due to an intrusive, perhaps a conquering tribe. The author was of opinion that the whole of the remains belonged to an extremely remote period.

Mr. Edward Peacock, F.S.A., described the opening of a barrow at Chatham, Lincolnshire. The approximate dimensions of the mound were 114 feet by 75 feet, with a central depth of 9 feet 6 inches. Three interments were discovered: one in the centre; another at 42 feet south (of a youthful subject), and another at 40 feet north of the centre; all accompanied by urns of a Celtic type. The work of excavating was particularly interesting, as showing the manner in which these mounds were constructed, the materials being carried in baskets or panniers; each basketful of sand could be distinctly traced.

3. ASTRONOMY.

(Including the Proceedings of the Royal Astronomical Society.)

At the General Meeting of the Astronomical Society on February 12th, it was announced that the gold medal for the year had been awarded to Mr. Stone, of the Greenwich Observatory, for his labours towards the determination of the sun's distance. We have already had occasion to refer at intervals to the various papers which Mr. Stone has written upon this subject; and a reference to the accompanying review of the proceedings of the Astronomical Society will show that he is still engaged on the same interesting work. What he has done may be divided into two sections: first, independent solutions of the problem of determining the sun's distance; and secondly, the careful re-examination of the observations and calculations of others. He has detected numerical errors in the processes of Leverrier and other mathematicians, besides errors of interpretation in the work of those who investigated the transit observations made in 1769; and he has given a large share of attention to the consideration of the proper means of weighing discordant observations,—a question of great difficulty, which largely enters into the problem of determining the sun's distance. The result of his labours has been to show that the sun's equatorial horizontal parallax is probably about $8''\cdot91$; his distance, therefore, about 91,700,000 miles.

Major Tennant's account of his work during the great eclipse of August last, had not led us to form very hopeful expectations respecting the photographs taken by his party. Fortunately it has turned out that these photographs were much better than Major Tennant had supposed. Mr. De la Rue suggested that it would be advantageous to take enlarged pictures of the photographs on glass, and to etch them according to the plan which he had used for the eclipse of 1860. In reference to this suggestion, Major Tennant wrote to Mr. De la Rue, that "the large pictures were thin and poor, and there was no use in treating them by etching; for the real thing would be better shown by a distribution of transparencies, so as to make them generally accessible." Accordingly Major Tennant sent eight sets of transparent copies on glass of his eclipse pictures to the Astronomer-Royal for distribution. One of these sets has reached Mr. De la Rue's hands. He says of them —and no one is better able to judge — "they are extremely interesting, and must be considered as eminently successful results." They contain much more detail than can be seen in the paper copies.

The two most important features exhibited in Major Tennant's photographs are: first, the spiral conformation of the Great Horn, marked A in the drawings (the only prominence which was visible *throughout* the totality); and secondly, the well-defined elevations indicated by a soft light, altogether different from that of the red prominences. "These entities," says Mr. De la Rue, in reference to the fainter light, "bounded by outlines which blend almost imperceptibly into the general light of the corona, are deserving of especial study, which will be best accomplished by means of photography, as it truly records their faint contours, which are likely to be overlooked in eye observations, because they are lost in the softened light which surrounds the moon, and also because the eye is naturally attracted most by the prominences which have a distinct outline."

It appears that the alterations which have taken place in the nebula round η Argûs are not nearly so important as Mr. Abbott's papers had seemed to indicate. In a letter sent to Sir John Herschel on this subject, Lieutenant Herschel (his son) remarks that the nebula is not only a very difficult object to draw properly, but that its appearance varies under every change of illuminating and magnifying power or of atmospheric conditions. He has carefully marked down the place of every conspicuous star in the nebula, and Sir John Herschel finds no difficulty in identifying all of these stars (except one small one) with those he had himself mapped down when at the Cape. Again, it is clear from Lieutenant Herschel's drawings that the closed lemniscate vacancy seen by Sir John Herschel thirty years ago, has not been replaced by a vacancy

extending along two perfectly open channels to the boundary of the nebula. On the contrary, a closed figure is shown in the drawings just sent, which, though not agreeing exactly with the older drawings, yet presents no difference which may not fairly be ascribed to the effect of using so much smaller a telescope in the recent observations. On the other hand, there is no doubt that the visibility of the nebula has largely increased in recent times. Lieutenant Herschel says that the eye catches the nebula as readily as the Pleiades. When Sir John Herschel was at the Cape the nebula was not visible to the naked eye. We can hardly suppose that so remarkable a change as this can be wholly due to the diminution of η Argûs from the first to the sixth magnitude. This variation might certainly enable the eye to recognize a nebulosity before invisible, but it could not bring out the nebula as a distinctly marked object.

Mr. Huggins has succeeded in seeing the red prominences round the sun by the aid of coloured glasses having the power of absorbing nearly all rays, except those belonging to the red part of the spectrum in which the C line of the prominences is found.

Notices of the Astronomical Society.

Mr. Tebbutt supplies a paper on the Solar Eclipse of August 18th last, as observed at Windsor, New South Wales. At that place only about one-third of the sun's diameter was eclipsed.

Mr. Huggins refers to observations which he had made during the past two years for the purpose of obtaining a view of the red prominences seen during a solar eclipse. The report of his observatory refers to the fact that the spectra of the prominences should be visible if those bodies are gaseous. He goes on to describe the contrivances by which he attempted to isolate portions of the spectrum. It appeared to him highly probable that if the parts of the spectrum which remained after certain portions had been absorbed were identical with those in which the bright lines of the flames occur, these objects would become visible. But as he had no knowledge of the position of the bright lines in the spectrum, "it would have been only by accident," he remarks, if he had succeeded. We have seen elsewhere that he has now succeeded in making the prominences visible by this method.

The same idea appears to have occurred to Lieutenant Herschel, who communicated his views on the subject in a letter to his father, Sir John Herschel. The letter remarks that this suggestion shows how immediately and readily a clearly-defined new fact suggests to an active and combining intellect the possibility of immediate practical application. "If I mistake not," he adds, "the double discovery

made by Mr. Lockyer and M. Janssen, of a mode of rendering the prominences *sensible* (not visible) turns on the same feature."

Mr. S. Newcomb discusses Mr. Stone's rediscussion of the transit of Venus in 1769. He endeavours to show that Chappe cannot be assumed to have observed an apparent internal contact of Venus instead of the real one, or "the formation of the black drop" as it is termed. Certainly, Chappe's words are not clear. After describing the undulating appearance of both the sun and Venus, he goes on to say,—"A ce .remier contact Vénus s'est allongée plus considérablement que le matin, en s'approchant tout-à-coup du bord du soleil." One might interpret this to signify that the elongation of the disc (the pear-shaped figure it assumes) was more remarkable at the egress than at the ingress; or that the sudden leap, so to speak, by which the edge of the planet's disc is carried forward to that of the sun's, covered a greater range than the corresponding phenomenon (reversed) at ingress. Mr. Stone takes the passage to signify that the elongation was of a more complete kind, so that a *broader* (not a longer) connecting-band was seen; in other words, Mr. Stone holds that Chappe missed the formation of the narrow ligament owing to atmospheric undulations, and first saw some phase much nearer to the apparent internal contact. Weighed by results, Mr. Stone's view has clearly the advantage over Mr. Newcomb's. As Mr. Stone remarks, "If the observer's words are doubtful, and we find that by assuming he observed an apparent contact all the observations are rendered accordant, whilst by assuming that he has observed a real contact all the observations are rendered discordant, it is not only permissible but necessary that we should assume that apparent contacts were observed.

Mr. Stone draws from the results of the observations made at Greenwich upon the transit of Mercury in November last, that the three following points should be carefully attended to in future observations of the more important transits of Venus:—

1. That telescopes of nearly the same aperture should be employed.

2. That very nearly the same magnifying powers should be employed by all the observers.

3. That attention should be directed to observations of real internal contacts as the chief points.

The words "real internal contacts," it is to be observed, refer to the formation of the black drop, which is undoubtedly simultaneous with the true internal contact of the planet's limb with the sun's.

Mr. Stone has extended to 1867 the calculations he had made respecting the constant of nutation, as determined from the observations of the pole-star with the transit-circle of the Greenwich Observatory from 1851 to 1865. Taking these observations, thus

extended, in combination with those made upon Cephei 51 and δ Ursæ Minoris from 1851 to 1865, he obtains for the final value of the constant of nutation

$$9''\cdot 134 - 0\cdot 55\, p + 2\cdot 02\, \delta p + 0\cdot 29\, \delta m - 0\cdot 6\, \delta c.$$

where p, δp, δm, and δc are the possible errors in the assumed estimates of the proper motion of the pole-star in R. A, and N. P. D, and of δ Ursæ Minoris, and of 51 Cephei in N. P. D. respectively. On account of the bearing of the constant of nutation upon our estimate of the moon's mass and of the sun's distance, these investigations are of extreme importance.

The Astronomer-Royal has supplied another of his valuable papers on the preparatory arrangements which will be necessary for the efficient observation of the transits of Venus in the years 1874 and 1882. It is almost impossible fairly to represent the nature of the present paper in the brief space available in these pages. Indeed the eight octavo plates which accompany the paper, and the two which illustrate Mr. De la Rue's paper on the same subject, are very necessary to the proper interpretation of Mr. Airy's remarks. But while referring the reader who would thoroughly master the views presented in these admirable essays to the papers themselves, we may point to the following important conclusions derivable from Mr. Airy's calculations:—

1. For observing the ingress of Venus as accelerated by parallax (in 1874), Owhyhee and the neighbouring islands, the Marquesas Islands, the Aleutian Islands, and the mouth of the Amoor are more or less favourably situated.

2. For observing the ingress retarded by parallax, Kerguelen Island and Crozet's Island are well situated though geographically unfavourable. Next in order come Rodriguez, Mauritius, and Bourbon Islands, Madras, and Bombay.

3. For observing the egress accelerated by parallax, a part of the Southern Continent if available would be the best place. Passing this region over, we come next to the Auckland Islands, Canterbury, Wellington. and Auckland, Norfolk Island, Melbourne, and Sidney.

4. For observing the egress retarded by parallax, Omsk, Orsk, Astrachan, Erzeroum, Aleppo, Smyrna, and Alexandria are well situated.

All these cases refer to the transit of 1874. As regards the transit of 1882, it is noteworthy that there is a possibility of applying the same method as was employed in 1769,—that is, determining the sun's distance from the different duration of the transit as observed from different points of the earth's surface. This method, Mr. Airy remarks, fails altogether in 1874, and there is not much prospect of its being successfully applied in 1882. Both these transits take place in December, when the southern or sea-

hemisphere of the earth is turned towards the sun. The transits of 1761 and 1769 took place in June, when the northern hemisphere was bowed towards the sun. Hence, principally, arises this important difference between the approaching pair of transits and the pair observed last century.

Failing observations on the duration of the transit in 1882, the accelerated and retarded ingress, and the accelerated and retarded egress, may be respectively observed from the four following sets of stations:—

1. Kerguelen, Crozet's, Bourbon, Mauritius, and Rodriguez Islands.

2. Every city near the seaboard of the United States, and every important city of Canada, also Bermuda, Jamaica, and the West Indian Islands.

3. The stations mentioned under 2, and the coast of South America from the Isthmus of Darien to Rio Janeiro.

4. Parts of the Antarctic Continent, Sydney, Melbourne, and parts of New Zealand.

If the durations of transits are to be observed, then certainly portions of the Antarctic Continent will have to be selected. Captain Richards, Captain Toynbee, Rear-Admiral Ommanney, and Staff-Commander J. E. Davis, supply some remarks on the geographical difficulties to be encountered in finding stations in high southern latitudes, but the examination of their papers would lead us away from astronomical considerations.

Mr. De la Rue gives an interesting paper on the possibility of taking photographs of Venus in transit. If this were done at several well-separated stations, it seems clear that a most important auxiliary means of estimating the sun's distance would be afforded. Mr. De la Rue points out that the close correspondence between the results obtained by micrometrical measurements applied to his eclipse-photographs in 1860, and the elements calculated by Mr. Farley, of the 'Nautical Almanac' office, show that a very close approximation to the truth is to be looked for in the case of the transit of Venus. For the difficulty of measuring the solar and lunar discs presented in an eclipse-photograph is very much greater than that attending the corresponding measurements in the case of a transit-photograph. And moreover, the observer of a transit would not be hurried like the observer of an eclipse, since the former phenomenon is several hours in progress, while the latter lasts but a few minutes.

Mr. De la Rue deals with the optical and physical corrections which would have to be made, showing how the distortion due to the optical peculiarities of the telescope could be determined beforehand, and suggesting that the experiments which appear to show that the collodion in drying shrinks only in the direction of its

thickness might be repeated if any doubts still remain as to their correctness.

He remarks in conclusion, "No difficulties exist in photographing a transit of Venus; the operations are quite the same as those practised daily at the Kew Observatory; no strain on the nerves would occur as in the anxiety consequent on the desire of rendering available every moment of the short duration of a solar eclipse. All the operations could be conducted with that calm so essential for such a problem as the determination of the solar parallax, and I feel confident in recommending that timely steps should be taken to secure photographic records of the transits of Venus in 1874 and 1882."

A paper by Mr. A. Marth draws attention to the observations which should be made upon Mars during the present opposition. His calculations respecting the presentation of the planet correspond closely with those on which we founded the views of Mars which appeared in our last Chronicle. Mr. Marth invites observers to send in any drawings they may make or have made of Mars, in order that they may be arranged in the order of their areographical longitudes and latitudes. He proposes so to combine them as to form a new map of Mars. We have very little hope that any ordinary drawings will throw much new light on the conformation of the Martial continents and seas. Those of Mr. Dawes are so far in advance of anything that has yet been attempted (so far at least as fullness of detail is concerned) that little seems to be promised by the examination of inferior drawings. What seems more hopeful is the fact that new and larger telescopes are now being directed to the examination of Mars by well-practised observers. Amongst others we may mention Mr. Browning, who is now observing the planet on every favourable night with his fine 12-inch reflector.

Professor Kirkwood remarks respecting the meteor-shower of November last, that its duration was much greater than that of former showers. "As seen in Europe in 1866, and in America in 1867, the display was limited to three or four hours. Last November, however, it commenced on the night of the 12th, and had not ceased at daylight on the morning of the 14th. This would indicate considerable irregularity in the thickness of the stream." Regarding the meteor-zone as in a sense the tail of Tempel's comet (Comet I., 1866), we can understand the peculiarity here referred to, as corresponding to the expansion of the visible tails of comets, with increased distance from the nucleus. Doubtless in a few years this expansion will have attained such an extent, and the meteors will be so far apart, that there will be properly speaking no shower, though meteors will continue to be comparatively plentiful on the nights of the 12th, 13th, and 14th November.

Mr. Birt discusses at considerable length the subject of the Lunar Crater Linné. From the drawings made at different times by Messrs. Huggins, Noble, and Tacchini, he has estimated the dimensions of the cone, crater, and orifice of this interesting object. He remarks that these estimates must be received as approximations only, serving rather as a guide to observers than as being expressions of the exact state of Linné at the present epoch. Those who see in the varying appearance of Linné a proof of the activity of lunar volcanoes in the present day, should study the researches of Mr. Birt on the probable configuration of the crater.

Mr. Kincaid suggests an ingenious mode of constructing an automatic transit instrument. The apparatus consists of a plane mirror and a burning-glass, to be adjusted in such a manner that, at the instant the sun reaches the meridian, the rays ignite a thread which burns without smoke or residue; this releases a detent, and a motion is thereby given to the hands of the clock, bringing it to the correct local mean time. There is a supplementary arrangement by which if the thread should not ignite, in consequence of a passing cloud, at the instant of the transit of the first limb, the subsequent ignition of the thread will not affect the clock.

Mr. Lockyer, in a note on Mr. Huggins's paper "On a possible Method of viewing Red Flames without an Eclipse," writes to show that he was not aided by the eclipse observations in seeking for the prominence-spectrum. Unless Mr. Lockyer claims credit for the discovery of the gaseity of the prominences, apart from the credit due to him for his share in the discovery that their spectrum can be seen without an eclipse, we cannot see how Mr. Huggins's mistake (assuming it to be such) at all affects the proper apportionment of recognition in the matter of recent solar discoveries. The eclipse observers clearly deserve all the credit due to the first-mentioned discovery, which had been fully discussed in England for two months before Mr. Lockyer examined the prominence-spectra. It is impossible to undiscover the discovered. On the other hand, no one has disputed the claim of Janssen and Lockyer to the discovery that the prominence-spectra can be seen without an eclipse.

Professor Brayley supplies an interesting paper on the relation of the luminous prominences to the faculæ of the sun. He shows that there is strong reason for supposing the faculæ and prominences to be identical, or at least that the latter are the superior terminations of the former.

Some very singular facts connected with the mean distances of the asteroids and the commensurability of their periods with that of Jupiter are pointed out by Professor Kirkwood. He shows that wherever there is a wider gap than usual between the asteroids (considered in the order of their distances from the sun), that gap invariably corresponds with such values of the mean distance as

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would give a period having some simple association of commensurability with the period of Jupiter. It is well known that any such association would result in disturbance, and Professor Kirkwood argues that the particles which, on the nebular hypothesis, would have occupied these vacant zones, must have been so disturbed by Jupiter, as to adopt eccentric orbits, and so come into collision with exterior or interior particles. Even if this did not happen, the disturbance of their orbits would lead to a change of period and so of mean distance. Either result serves to account for the gaps in the asteroidal zone. He considers that very strong evidence is afforded by these coincidences (which certainly cannot be looked upon as accidental) in favour of the nebular hypothesis. He goes on to examine the Saturnian rings, which he remarks have been quoted in Proctor's Saturn as furnishing strong evidence of the nebular hypothesis of Laplace. He shows that the great division between the rings corresponds exactly with that portion of the width of the system where the particles would move in periods commensurate with those of the four inner satellites. The coincidence is certainly most remarkable. The whole paper is well worthy of careful study, being founded on well-established mathematical principles, and serving to bring together and account for a number of remarkable relations in the solar system.

Mr. Stone supplies a paper upon Aboul Hhassan's catalogue of 240 stars, which he shows to have been derived from Ptolemy's catalogue, and not (as Delambre had supposed) from Arzachel's. It is known that Ptolemy derived his catalogue from that of Hipparchus by applying an erroneous correction for precession. Mr. Stone shows how this fact may have led to the Arabian notion that the precessional motion is oscillatory. "If this view be correct," he says, "Ptolemy's want of candour respecting the nature of his catalogue is thus found to be throwing astronomy into complexities more than 1100 years after his death."

4. BOTANY, VEGETABLE MORPHOLOGY AND PHYSIOLOGY, AND ECONOMIC BOTANY.

Sterility of Hermaphrodite Flowers.—Mr. Thomas Meehan has observed that the flowers of *Epigœa repens* are practically diœcious —since the hermaphrodite flowers are sterile. He is led to speculate upon this observation, as to whether the diœcious character may not be a result of subsequent changes in the development of a once monœcious form, and suggests that all plants would be primarily monœcious but that there is a kind of exhaustion of the

form—an old age of the race, as of the individual—when accordingly hermaphrodite fertilization becomes inefficient, and it becomes necessary that the sexual elements of distinct races should be combined to ensure the continuation of the species.

The Botany of the Malvern Hills.—Such spots as the Malvern Hills are peculiarly interesting to the botanist as well as to the geologist, and it is because they have special geological features that they present special botanical developments. The supposed igneous or metamorphic axis of the Malvern anticlinal carries with it a certain peculiarity of vegetation which is not met with in the immediately surrounding country, and, in addition to this, the height of the Hills has rendered them the refuge for Alpine forms when the Straits of Malvern flowed over the Severn valley. Mr. Edwin Lees, the Vice-President of the Malvern Field Club, has brought out the third edition of his little book on the flora of this district, which must be of great service to those who wish to explore the range and make the acquaintance of its botanical rarities. A sketch of the geology and physical geography of the range is also given, which appears to be considered—and very rightly—a necessary accompaniment of a local flora in these days. It is not only, however, by giving the two sets of facts, the botanical and geological, that the students of local floras should set forth the important connection of the two studies, but by tracing out in detail and completely the history of a flora as influenced by geological changes and the nature of the soil. To do this well requires great study and much extended observation. Mr. Lees unfortunately uses the Linnæan system, which really diminishes the value of his book. A special feature of interest in the volume is the recognition of the cryptogamic species, which often are passed over in silence in handbooks and pocket floras. Mr. Lees is a well-known student of these forms, and his account of them may be considered the most valuable part of his 'Botany of the Malvern Hills.'

The Malvales.—Dr. Maxwell Masters having carefully examined the relations of the families Malvaceæ, Sterculiaceæ, and Tiliaceæ of Bentham's and Hooker's Cohors VI., has arrived at the conclusion that though it may be desirable for convenience sake to separate the two former from each other, yet they are so closely related morphologically, that it is not possible to understand the peculiar structural relations of the one without comparing them with the corresponding parts of the others. Dr. Masters considers the stamens as organs of the highest importance in classification. "Not only," he says, "does the connection of the stamens furnish one of the best characters of the entire group, but even in the discrimination of the smaller sub-divisions (genera) the appearances presented by the column are of the greatest value."

Oblique Leaves.—In a late volume of the Boston Society of Natural History, Dr. Wilder shows that in the Elm the larger portion is in the upper or most elevated side; the leaves not lying with their edges horizontally. In the Hornbeam the outer or lower portion is the largest. De Candolle and Herbert Spencer have both tried to account for obliquity in leaves, but Dr. Wilder considers their reasoning to be insufficient. Dr. W. believes it to be caused by no external agency, but by an inherent constitutional force. The German botanists, especially Schimper and Braun, have long since investigated the development of leaves in connection with the general subject of phyllotaxis. They found that each leaf was primarily a swelling or wave of growth freeing itself from the axis of the embryo; and that differences in size between the sides of a leaf were caused by the greater force of the wave in its upward or downward movement. Such peculiarities as have been pointed out between the leaves of the Elm and the Hop Hornbeam exist therefore in the earliest formation of the leaf, while yet connected with the axis by a broad base, and before any constriction for the petiole has taken place. Professor Agassiz considers the word "antistrophe" as better expressing the inverse relation of corresponding parts on the opposite sides of a line than "symmetry." Dr. Wilder has shown that the corresponding leaves on each side of a shoot are symmetrical.

The Rubi, of Plymouth.—The Rev. A. Bloxham names a new Rubus after Mr. Briggs, who has recently given a very interesting account of the stations of the Rubi in his own neighbourhood. The marvellously protean genus *Rubus* is one of the most interesting studies at the present time for English botanists. By careful examination we may hope to see definite relations of cause and effect pointed out between the various species and their stations.

The Culture of Opium.—Mr. Heffler, of Smyrna, describes some of the difficulties and risks attending the cultivation of the poppy in Asia Minor. The agricultural implements used are most primitive, and no irrigation is applied. The poppy must be grown in a moist but not a too wet soil, and hence is very much subject to injury from variations of season. Accordingly it is sown at three different periods of the season, so that if one crop should fail, another may have a chance of success. This method also enables the labourers to gather first one field and then another, which is desirable from the scarcity of hands and the necessity of gathering just at the right time in the plant's development. When the seed capsule is considered to have arrived at maturity, the gatherers go into the fields and in a very skilful manner make horizontal and vertical incisions in the outer portion of the capsule, being very careful not to penetrate to the seeds. On the morning following this operation, the cuts are found to be covered with

milky juice which has oozed from them, and which the gatherer scrapes off with his knife and wipes on a leaf. When he has accumulated a sufficient quantity on a leaf to make a ball, it is rolled up and left to dry in the sun. The period between the making of the incisions and gathering the juice is a very critical one, for should a shower of rain come on, as it often does at this season, the juice is entirely lost. The opium-growers are generally small landowners, who superintend the cultivation themselves with their families. The cakes are bought by travelling merchants, who convey them in sealed bags to Smyrna, and some few to Constantinople, where the bags are opened after being sold to the city merchants. Then they are carefully examined for adulteration and as to quality, three qualities being distinguished. It requires the greatest skill and long experience to become a good judge of opium cakes—odour, weight, texture, &c., being all important.

Akazga.—Akazga is a poison known from the reports of travellers, used as an ordeal on the west coast of Africa, and found by two French chemists to exert physiological effects similar to those of nux-vomica. A supposed sorcerer is made to drink an infusion of Akazga bark and then to walk over small Akazga sticks. If guilty, he stumbles and tries to pass the sticks as though they were great logs, eventually falling in convulsions and being clubbed by the surrounding savages. If innocent, the kidneys are said to act freely, and the poison is supposed to be thus eliminated. Dr. Fraser, of Edinburgh, has received specimens of Akazga in bundles of long, slender, and crooked stems, and examined its botanical relations and chemical properties. Consulting with Professor Oliver, of Kew, Professor Balfour, of Edinburgh, and Professor Dickson, of Glasgow, he comes to the conclusion that the Akazga plant is new to the flora of West Africa, and he supposes it may be a new species of Strychnos. He has succeeded in separating from it a crystalline alkaloid, closely resembling Strychnia, but differing from it in being precipitated by alkaline bicarbonates. Dr. Fraser made a careful comparison of the microscopic structure of the stems of Akazga and Strychnos nux-vomica, and was thus able to separate them still more closely. Amongst the parcels of Akazga which he examined, were certain twigs which had a different stem-structure, and failed to yield the chemical products of the other specimens. Is it not possible that those who escape in the ordeal may have been fortunate enough to get an infusion prepared from this "false Akazga" by mistake? Dr. Fraser terms the new alkaloid *Akazgia.*

The Uses of Pine Leaves.—In a paper lately read before the Society of Arts, Mr. P. L. Simmonds states that a new and curious application of a waste product is the utilization of the acicular leaflets of pine trees. Near Breslau, in Silesia, are two establishments, one a factory where the pine leaves are converted into what

is called "forest wool," or wadding; the other, an establishment for invalids, where the waters used in the manufacture of this pine wool are employed as curative agents. The manufacture has extended, for there are now factories at Runda, in the Thüringer-Wald; at Yonkoping, in Sweden; Wagenerger, in Holland; in parts of France, and other places. Two cases of these products were shown at the last Paris and Havre exhibitions, which contained various illustrations, in the shape of wool for stuffing mattresses and other articles of furniture, instead of horse-hair; vegetable wadding, and hygienic flannel for medical application; essential oil for rheumatism and skin diseases; cloth made from the fibre; articles of dress, such as inner vests, drawers, hose, shirts, coverlets, chest preservers, &c., and other useful applications. In the preparation of the textile material an ethereal oil is produced, which is employed as a curative agent for burning, and as a useful solvent. The liquid remaining from the decoction of the leaves is used for medical baths. The membranous substance and refuse are compressed into blocks and used as fuel; from the resinous matter they contain, sufficient gas is produced for illluminating the factory in which the manufacture is carried on.

The Structure of the Diatomaceous Frustule.—Dr. John Denis Macdonald, F.R.S., of the Royal Navy, has published a very elaborate paper on the composition of the Diatom's shell, and the part it plays in the process of division. He finds the views expressed in the writings of Dr. Wallich (particularly in his paper on Triceratium, and on the diatom-valve, in the 'Quarterly Journal of Microscopical Science') most in accordance with his own independent researches. Dr. Wallich appears to have been the first to set forth clearly that the middle piece, or "zone," running round between the two large valves of the diatom, consists, while the frustule is intact, of two distinct plates, the one received within the other; and that the growth of such plates can only take place at the free margins, or those which are not connected with the valves. Dr. Macdonald shows that by the process of division (valve being formed within valve), the resulting diatom will ultimately become reduced to a very small size; and he observes that the species would be indefinitely diminished were it not for the process of conjugation, in which Mr. Thwaites showed that the produced sporangial frustule was very much larger than the parent cells. This diminution of size is very well illustrated in a diagram representing the progeny of the two valves of a divided *Biddulphia*, and by it the ultimate relations of the dividing frustules are exhibited.

Reproductive Organs of Lichens.—MM. A. Famitzin and J. Boranetsky have been recently investigating this matter, and are led to conclude that—

1. Not only algæ and fungi, but lichens also, are provided with zoospores.

2. Zoospores have been discovered in three very different genera of lichens, viz. *Physcia*, *Cladonia*, and *Evernia*; and as these genera were selected undesignedly, it is probable that zoospores exist in all other lichens furnished with chlorophyll.

3. The identity of free gonidia with unicellular algæ (Cystococcus of Nägeli) may be considered as demonstrated; consequently this is not a distinct genus, but only a phase of development of a lichen.

4. The culture of the freed gonidia of *Physcia*, *Cladonia*, and *Evernia* led us to expect that other lichens would afford forms corresponding with rudimentary algæ. Our researches prove this to be well founded. Vertical sections of the thalli of *Peltigera* and *Collema*, cultivated on moist earth, showed the filaments in disintegration, the augmentation in size of the gonidia, and their transformation into glomerules composed of spherical cellules. The gonimic cellules of *Peltigera* and *Collema* continued to live when separated from the thallus; those of *Peltigera* were identical with an alga called *Polycoccus*; those of *Collema* produced organisms similar to *Nostoc*. Consequently these three genera of algæ, hitherto regarded as distinct, are in reality only the gonidia of lichens in a state of development when separated from the thalli which produced them.

New Lichens.—The Rev. J. Crombie describes in the 'Journal of Botany' a number of new lichens from the well-searched neighbourhoods of the New Forest and Scotch moors. What he has been able to do is an encouragement to others to pursue the very fascinating study of these little plants; taking the student over mountain rocks, among old ruined towers, or under vast and aged tree stems—with a geological hammer and a strong knife in his hand, and no need of great tin-boxes and blotting-paper.

Deaths.—Carl von Martius, the great botanist and traveller, died at Munich, in December last, aged 74. Adalbert Schnitzlein, Professor of Botany at Erlangen, died in October, from the result of an accident whilst botanizing in the Tyrol.

The late Professor Harvey.—Those who would like to read the history of a good, well-loved, and great botanist should see the recently-published memoir of the late Professor of Botany in Trinity College, Dublin.

The Chair of Botany at Trinity College, Dublin.—We are glad to find that the fears of Dr. Wright's friends as to the election to the late vacancy in Dublin have not been fulfilled. Trinity College has not followed the nomination of the Science and Art Department, and Professor Wyville Thomson, though appointed lecturer in the Government College of Science, has not obtained the University chair, to which Dr. Edward Perceval Wright has been elected.

5. CHEMISTRY.

WITHOUT exception, the most important contribution to chemical science which has been published for some time is the paper recently read by Professor Graham, the Master of the Mint, on Hydrogenium. The author discovered some time ago that the metal palladium was capable of absorbing, or *occluding*, as he terms it, 800 or 900 times its volume of hydrogen; and the idea has forced itself upon his mind, that palladium with its occluded hydrogen was simply an alloy of a volatile metal hydrogen, in which the volatility of the one element is restrained by its union with the other, and which owes its metallic aspect equally to both constituents. How far such a view is borne out by the properties of the compound substance in question, will appear by the following examination of the properties of what, assuming its metallic character, may be named hydrogenium:—

The density of palladium when charged with 800 or 900 times its volume of hydrogen gas is perceptibly lowered, being reduced from 12·3 to 11·79; and, ultimately, as the mean of several concordant experiments, the density of hydrogenium was found to be 1·951, or nearly 2.

The tenacity of the hydrogen-charged wire was found to be 81·29, that of the original palladium wire being 100. It is seen, therefore, that the tenacity of the palladium is reduced by the addition of hydrogen, but not to any great extent. It is a question whether the degree of tenacity that still remains is reconcilable with any view other than that the second element present possesses of itself a degree of tenacity such as is only found in metals.

The electric conductivity was tested by submitting a palladium wire before and after charging with hydrogen to trial, in comparison with a wire of german silver of equal diameter and length, at 10·5°. The conducting power of the several wires was found as follows, being referred to pure copper as 100:—

Palladium	8·10
Palladium + hydrogen	5·99

A reduced conducting power is generally observed in alloys, and the charged palladium wire falls 25 per cent. But the conducting power remains still considerable, and the result may be construed to favour the metallic character of the second constituent of the wire. As regards magnetism it was found that the addition of hydrogen to palladium added manifestly to the small natural magnetism of palladium. It follows, therefore, that hydrogenium is magnetic, a property which is confined to metals and their compounds. This magnetism is not perceptible in hydrogen gas,

which was placed both by Faraday and by M. E. Becquerel at the bottom of the list of diamagnetic substances. This gas is allowed to be upon the turning point between the paramagnetic and diamagnetic classes. But magnetism is so liable to extinction under the influence of heat, that the magnetism of a metal may very possibly disappear entirely when it is fused or vaporized, as appears with hydrogen in the form of gas. As palladium stands high in the series of the paramagnetic metals, hydrogenium must be allowed to rise out of that class, and to take place in the strictly magnetic group, with iron, nickel, cobalt, chromium, and manganese.

The chemical properties of hydrogenium distinguish it from ordinary hydrogen. The palladium alloy precipitates mercury and calomel from a solution of the chloride of mercury without any disengagement of hydrogen; that is, hydrogenium decomposes chloride of mercury, while hydrogen does not. Hydrogen (associated with palladium) unites with chlorine and iodine in the dark, reduces a persalt of iron to the state of protosalt, converts red prussiate of potash into yellow prussiate, and has considerable deoxidizing powers. It appears to be the active form of hydrogen, as ozone is of oxygen. A wire charged with hydrogen, if rubbed with the powder of magnesia (to make the flame luminous), burns like a waxed thread when ignited in the flame of a lamp.

The general conclusions which appear to flow from this inquiry are—that in palladium fully charged with hydrogen, there exists a compound of palladium and hydrogen in a proportion which may approach to equal equivalents; that both substances are solid, metallic, and of a white aspect; that the alloy contains about 20 volumes of palladium united with 1 volume of hydrogenium; and that the density of the latter is about 2, a little higher than magnesium, to which hydrogenium may be supposed to bear some analogy; that hydrogenium has a certain amount of tenacity, and possesses the electricial conductivity of a metal; and finally, that hydrogenium takes its place among magnetic metals. The latter fact may have its bearing upon the appearance of hydrogenium in meteoric iron, in association with certain other magnetic elements.

A paper on meteoric iron has been communicated by M. Stanislaus Meunier to the 'Chemical News.' The numerous researches hitherto made with regard to the composition of meteoric irons have demonstrated in these extra-terrestrial bodies the existence of the following compounds:—

1. The general mass which is formed by the union of several alloys in which iron and nickel are predominant, and which we will designate under the name of nickeliferous iron. Among the substances comprised in this mass, the *Ramacite*, the *Tœnite*, and the *Plessite* will be specially mentioned.

2. The carburetted iron, comprising the *Campbellite* and the

Chalypite, recognizable by the carboniferous deposit which they give under the action of acids.

3. The sulphuretted iron, or *Tröilite*, which appears in nodules and in veins.

4. The phosphide of iron and nickel or *Schreibersite*. 5. *Graphite*. 6. The external crust. 7. The stony particles or crystals. 8. The gases retained by occlusion. 9. Several compounds which are only met with exceptionally, as *Chromite*, &c. Space will not allow us to give in detail the very ingenious methods adopted by the author for separating these different substances. It must be sufficient to say that he has succeeded in isolating each of these components in a state of purity and ascertaining their composition, with the exception of the gases, owing to his having employed for their separation a method which Professor Graham has since shown to be inapplicable.

Professor Stas, to whose researches chemists are so much indebted, has published a modification of Gay Lussac's method of estimating silver in the wet way. In the ordinary process a standard solution of salt is employed, but, as the precipitated chloride of silver is soluble in a solution of salt, it is impossible to carry out this principle to the minute accuracy which is sometimes required. M. Stas has now discovered that by substituting a bromide for a chloride in precipitating silver, this error may be absolutely removed.

An Italian chemist, Massino Levy, has devised a method of preparing nitrogen gas, which may be useful in some cases. It consists in heating bichromate of ammonia in a retort; the salt is transformed into green sesquioxide of chromium, and disengages vapour of water and nitrogen gas. In the ordinary process of bleaching wood-pulp it is very difficult to avoid a yellow or reddish tint, and if iron is present the paste generally blackens in a very short time.

M. Orioli has discovered a process of bleaching in which these objectionable results are obviated. To 100 kilogrammes of wood-pulp, 800 grammes of oxalic acid are added; this serves the double purpose of bleaching the colouring matter already oxidized, and of neutralizing alkaline principles. Two kilogrammes of sulphate of alumina, free from iron, are now added. This does not bleach of itself, but it forms with the colouring matter of the wood a nearly colourless lake, which enables the brilliancy of the product to be heightened.

At one of the recent meetings of the Manchester Literary and Philosophical Society, Mr. Sidebotham drew attention to the large number of galls, which appeared to be much commoner now than they were a few years ago. They were produced by the gall fly, *Synips Lignicola*; and, from experiments which he had tried, it

appeared that the English galls were about two-thirds the value of the foreign ones, or, according to the present market value, they were worth about 66*s.* a cwt. The galls, even when in great numbers, do not appear to injure the trees. The proper time to collect them would be the middle of September, when the flies have all eaten their way out and laid their eggs for another year's supply. In the plantations where these galls abound, a man might collect easily half a cwt. in a day.

A not uncommon adulteration of glycerin is to mix sugar and dextrin with it. These substances have not hitherto been easy to discover when mixed with the glycerin; the following process is, however, said to answer perfectly:—To 5 drops of the glycerin to be tested, add 100 to 120 drops of water, 3 to 4 centigrammes of ammonium molybdate, 1 drop of pure nitric acid (25 per cent.), and boil for about a minute and a half. If any sugar or dextrin is present, the mixture assumes a deep-blue colour.

The abominable odour of bisulphide of carbon is a great bar to its employment in the arts. This, according to M. Millon, can soon be got rid of. The sulphide of carbon is first washed several times with distilled water, as in the purification of ether, and then transferred to a retort of large capacity containing quick-lime. After twenty-four hours contact the sulphide is distilled off from the lime, and received in a flask partially filled with copper turnings, previously roasted to remove all traces of fatty matter, and afterwards reduced by hydrogen. The lime remaining in the retort is strongly coloured. All the disagreeable odour of ordinary bisulphide of carbon is removed by this treatment, and when the nose is placed close to the mouth of the receiver, an ethereal odour is only perceived. With bisulphide of carbon thus purified, MM. Millon and Commaille have separated the perfume of milk to the extent of recognizing certain plants eaten by the cow—the *Smyrnium olusatrum* among others.

Professor A. Silvestri, of the University of Catana, has recently discovered a great quantity of citric acid in the fruit of the *Cyphomandra betacea,* a plant belonging to the family of *Solanaceæ* which is found here and there in the gardens of Sicily. It is indigenous to Mexico, and has spread itself into Peru and other parts of South America, where it is called *Tomate de la paz.* It is a woody plant, and attains to the height of 4 mètres. On analysis the fruit gives from 1 to 1·5 per cent. of pure citric acid. This acid, which probably exists also in our edible tomato, has already been discovered by Bertagnini in the potato, and will doubtless be found in all plants belonging to this tribe.

A plan of testing the strength of acetic acid, likely to be of great use to photographers and others, has been published in

the 'Photographic Journal.' It was observed, we believe, independently by M. Berthelot and Mr. E. Chambers Nicholson, that an acid which, although of a high degree of purity, is not glacial, becomes inflammable when the temperature is raised to the boiling-point. If we take, for instance, about a drachm of the acid of 95 per cent., and heat it in a test-tube to the boiling-point, it will be found that the vapour takes fire on applying a lighted match, and burns steadily as long as the ebullition is maintained; if, however, 10 per cent. of water be mixed with the sample, there will be great difficulty in causing inflammation, and the vapour, when ignited, will only burn with a lambent flame of pale-blue separated cones, whilst below this strength the acid vapour is altogether uninflammable. By this test then (avoiding a too prolonged ebullition, which increases the strength of a weak acid), we have a ready means of estimating the quality of liquid samples of a high degree of concentration, without resorting to the more tedious method of acidimetry. It has only to be stated, in conclusion, that the boiling-point of the ordinary qualities of acetic acid, although higher, is so little removed from that of water, that the indications of the thermometer are not much more to be relied upon than those of the hydrometer. In many respects carbolic acid imitates the deportment of acetic acid in the characters above described; it likewise becomes glacial upon separation of the last traces of water.

M. Chabrier has studied at nitrification works, in particular circumstances, the different degrees of oxidation of the nitrogen, and especially nitrous acid. He has devoted attention to the estimation of this acid in saline mixtures, where nitrites and nitrates occur together with reducing agents, and has submitted to the Academy the result of the first part of his researches. The facts contained in this memoir are deduced from the following conclusions:—1st, in liquids containing at the same time nitrites, nitrates, and organic matter, the nitrous acid of the nitrites may be determined by the decolourizing action which hyposulphite of soda exerts on the iodide of potassium in presence of starch, and dilute sulphuric acid; 2nd, in the absence of nitrates and organic matter, the determination could be more easily made by the decolourizing of indigo solution, operating with the aid of heat, but out of contact with the air.

A combination of iodic acid with oxide of ethyl has been prepared by M. K. Lisensko. He finds that a mixture of equal volumes of ethyl iodide, and dry ether, readily acts upon argentic iodate. If the temperature is not allowed to rise above 10° C., the liquid remains colourless, and the new ether undecomposed. The solution distils between 37° and 40°. The distillate at first floats upon the water with which it had been mixed, but on passing a current of air through the liquid, in order to drive off

ethyl ether, it sinks to the bottom of the vessel. All attempts at further purification failed; the liquid boils at 75° under decomposition. Organic chlorides are converted into iodides by the action of concentrated iodhydric acid. M. A. Lieben finds that this method of conversion seems to be a general one, and subject to limitation only in so far as some iodides at the moment of their formation are converted into hydride. Ethyl chloride, at 130° C., is almost completely converted into iodide, without evolution of gas or formation of any bye-product. The same is the case with butyl and amyl chloride.

Lipowitz has recommended the use of hypochlorite of lime (bleaching powder) as a means of detecting the adulteration of olive oil, and also of sweet almond oil, with the oil of poppy-seed. When eight parts of either olive oil or oil of sweet almonds is rubbed up and shaken with one part of bleaching powder, and left at rest, it will be seen that even after some four or five hours a layer of clean and limpid oil separates and floats at the top and surface of the mixture, which layer is, if the oils operated upon are pure, at least half the bulk of the original mixture; if, however, poppy-seed oil is mixed with either of the two oils just mentioned, and the same experiment then repeated, the mixture takes the appearance of a liniment, from which no oil separates. Sweet oil of almonds adulterated with one-eighth part of poppy-seed oil behaves as if it were almost pure poppy-seed oil. Büchner and Brande have found Lipowitz's statement correct as regards sweet oil of almonds, but not as regards oil of olives; but they add that the olive oil they operated upon was already old. The action of Lipowitz's reagent is explained by the fact of the rapid oxidation of all so-called drying oils, which on drying yield solid products before entirely changing, by continuously absorbing oxygen into water and carbonic acid. Linseed oil, hemp-seed oil, poppy-seed oil, oil from walnuts, croton oil, castor oil, are all drying oils. The drying of drying oils is, in fact, a process of slow oxidation of these oils.

Professor Parkes, F.R.S., of Netley, calls attention to the fact that it has always been seen that the action or non-action of water on lead could not be entirely accounted for by the usual statements on the subject; and lately Dr. Frankland has made a curious observation, which may throw light on the subject. He found that water which acted on lead lost this power after passing through a filter of animal charcoal. He discovered this to be owing to a minute quantity of phosphate of lime passing into the water from the charcoal. On comparing two natural waters, that of the river Kent, which acts violently on lead, and that of the river Vyrnwy, which, though very soft, has no action on lead, he found that the latter water contained an appreciable amount of phosphate of lime,

while none could be detected in the Kent water. This observation may probably explain much of the discrepancy of evidence in respect of the action of soft water on lead.

Professor Tomlinson has advanced a very good explanation of a circumstance which has often been a stumbling-block for students:—Why does hydrochloric acid fume when let out into the air, while ammonia, which has a much stronger attraction for water, does not? After making several observations of specific gravity, boiling-points, &c., Professor Tomlinson comes to the conclusion that, although ammoniacal gas and hydrochloric acid gas are greedily absorbed by water, there must be some important differences in the constitution of the respective solutions. The alkaline solution is much lighter than its own bulk of water, whilst the acid solution is much heavier; also the presence of ammoniacal gas in water lowers its boiling-point, while the presence of hydrochloric acid in water has a contrary effect. Hence the mode of combination between ammonia and water must be different from that between hydrochloric acid and water. The one must be a case of simple adhesion, the other of true chemical combination as well as adhesion. Ammonia let out into moist air simply adheres to the moisture, and increases its volume. Vapour of alcohol, ether, &c., does the same. Now any amount of aqueous vapour that the air can maintain in an invisible, elastic state, at a given temperature, it can maintain with increased effect in the case of ammonia vapour, alcohol vapour, &c. Hence the combination of these vapours with the moisture of the air is necessarily an invisible compound. Hydrochloric acid gas, on the other hand, let out into the air, combines chemically with the moisture, producing condensation or diminution of bulk. Hence the compound is visible, just as the condensation of pure steam in air produces visible vapours. Fuming nitric acid and Nordhausen sulphuric acid are also cases in point. Concentrated nitric acid, exposed to the air, absorbs moisture until it attains the density of 1·424, when it distils unaltered at a boiling-point of 250°.

Dr. Carter Moffat has succeeded in fixing on paper the beautiful figures which are produced when oils, &c., are allowed to fall drop by drop on a surface of pure water, and which Professor Tomlinson has shown to be characteristic of each oil. The method is very simple; and is, briefly, to obtain a pattern on water, note the time, lay on the paper, glazed side downwards, for an instant, take out, draw through a plate of ink, remove, and wash with water. The process is capable of great extension, and will be valuable to paper-stainers and others. Several books of *oleographs,* as these figures are called, have been presented by Dr. Moffat to different individuals interested in them, and have elicited cordial approbation.

According to M. Oser, every time that solutions of sugar ferment under the influence of yeast, besides alcohol, a new alkaloid is

produced. The chlorhydrate of this base crystallizes in hygroscopic tables, which become brown on exposure to the air. It appears that all fermented liquors contain the new alkaloid, or at least one of its compounds. The presence of such a substance in wine and in beer, till now entirely unknown, will doubtless explain certain effects of fermented liquors on the animal economy—effects which cannot be attributable to alcohol alone.

Proceedings of the Chemical Society.

The first meeting of the season took place on Thursday, Nov. 5, 1868, Dr. W. A. Miller, V.P.R.S., &c., Vice-President, in the chair.

The first paper read was by Mr. W. H. Perkin, "On the Hydride of Butyro-Salicyl and Butyric-Coumaric Acid." The author's previous communications had shown that hydride of aceto-salicyl is an intermediate stage in the formation of coumarin from acetic anhydride and hydride of sodium-salicyl. By the substitution of other anhydrides for the acetic, he had obtained homologues of coumarin, and he now describes the hydride of butyro-salicyl, which forms the intermediate stage in the synthesis of butyric coumarin, as hydride of aceto-salicyl does in that of ordinary coumarin. It is an oil boiling at 260°–270° C. Hydrate of potassium decomposes it into hydride of potassium-salicyl and butyrate of potassium, and it yields with acetic anhydride a compound perfectly parallel with those produced by the action of the anhydride on the hydrides of ethyl-salicyl, aceto-salicyl, &c. When boiled with butyric anhydride and butyrate of sodium it yields butyric coumarin. By the action of hydrate of potassium, butyric coumarin yields butyric-coumaric acid, a true homologue of ordinary coumaric acid, and, like it, capable of yielding only monometallic derivatives.

The next was one "On the Application of Chlorine Gas to the Toughening and Refining of Gold," by F. B. Miller, F.C.S., Assayer in the Sydney branch of the Royal Mint. The methods now in use for effecting the above purposes are all more or less unsatisfactory, and the author has therefore devised a process which appears to satisfy all the requirements of the case in a single operation. A French clay crucible is saturated with borax. The gold is then melted in this crucible with a little borax, and a stream of chlorine gas is allowed to pass through it by means of a tobacco-pipe stem. In a few hours the whole of the silver is converted into chloride, which floats on the gold. The borax prevents the absorption of the chloride by the crucible, and also its volatilization, except in very minute quantities. As soon as the gold has become solid, the still liquid chloride of silver is poured off, and the gold is now found to have a fineness of say 993 parts in 1000. The apparent loss of gold is very little

greater than is found in ordinary gold melting—being 2·9 parts in 10,000—whereas in the ordinary process it is 2. The Chairman, in proposing a vote of thanks to the author, remarked upon the great importance of the new process. Much of the gold imported into this country contained 60 or 70 ounces of silver in 1000, which could not at the present time be profitably extracted. The new method would probably be soon adopted by English assayers.

This was followed by a "Note on the Specific Gravity and Boiling-point of Chromyl Dichloride," by T. E. Thorpe, Dalton Scholar in the Laboratory of Owen's College, Manchester. The author prepared the liquid by distilling an intimate mixture of ten parts sodium chloride and twelve parts potassium dichromate with thirty parts strong sulphuric acid. He removed the free chlorine by repeated distillation in an atmosphere of carbonic acid. The specific gravity of the liquid so obtained was, at a temperature of 25° C., 1·92. The boiling-point, at a pressure of 733 millimètres, was found to be 116°·8. The dichloride cannot, however, be distilled without some slight decomposition.

The same author, Mr. T. E. Thorpe, then gave a paper "On the Analysis of the Ashes of a Diseased Orange Tree (*Citrus aurantium*)." The orange plantations along the south-eastern coast of Spain and in the adjacent Balearic Isles have recently been visited with a severe epidemic, the rapid progress of which was naturally viewed with no little anxiety by the people, since the culture and exportation of oranges constitute one of their principal industries. The origin of the disease is involved in complete obscurity, and as yet it has baffled all attempts at remedial measures. The first symptoms are observed in the leaves, which turn yellow and drop off; a most disgusting odour exhales from the roots, and in a few days the tree succumbs. The violence of the disease is now, happily, much abated, and it appears to be dying out. We have no space for the details of the analyses. Tables are given which show the percentage composition of the ash of the roots, stem, branches, and fruit, and the results are compared with the analyses of the ash of healthy plants made by Rowney and How, and by Dr. Richardson. The most remarkable differences observed in the comparison are given in the following table, showing the percentages of lime and phosphoric acid:—

	Lime.	Phosphoric Acid.
Root of diseased plant	61·82	1·57
Stem of ditto	70·67	2·66
Root of healthy plant	49·89	13·47
Stem of ditto	55·13	17·09

The phosphoric acid is thus shown to be in deficiency in the diseased plant, and the lime in excess. Similar differences cannot, however, be traced in the ash of the fruit.

At the meeting on November 19, 1868, Dr. Warren De la Rue, F.R.S., the President, in introducing the business of the meeting, observed that their object on the present occasion was to discuss certain proposed alterations in the bye-laws, by which a greater number of Fellows would be admitted to a share in the government of the Society. The Council had long felt anxious to effect this object; and finding that the Charter did not permit them to increase the number of the Council, they now proposed to raise the number of Vice-Presidents, who had not filled the chair, from four to six. This alteration would, it was felt, infuse some new blood into the governing body.

Formal alterations in the bye-laws, to provide for the proposed change, were then carried unanimously.

Mr. W. H. Perkin then made a communication "On the Action of Chloride of Lime on Aniline."—In this paper the author points out the difference between Runge's blue and aniline purple, and shows that the blue can be changed into the purple when decomposed by heat.

Professor Church gave an analysis of a meteorite from South Africa.

The meteor in question was seen by a native to fall at Daniel's Kuil, a place about two days' journey N.N.E. of Griqua Town. The native said it was warm, and smelt of sulphur, when he picked it up. He offered it to the Rev. James Good, a missionary in Griqua Town, who declined it, and recommended him to take it back to the place where he found it! Instead of doing so, he gave it to Captain Nicolas Waterboer, and from his hands it passed into those of Mr. J. R. Gregory, of Russell Street, Covent Garden, then at the Cape, and is now in the British Museum.

It was small in size, of an irregular oblong form, weighing 2 lbs. 5 oz. It was covered with a dark-grey crust, speckled here and there with reddish-brown spots, these spots arising from a partial oxidation of the ferruginous materials of the stone. Its density was rather low, namely, 3·657 and 3·678, as found in two determinations. The following was given as the analysis of the meteorite:—

Nickel-iron (containing 5·18 per cent. nickel), 29·72; Tröilite, 6·02; Schreibersite, 1·59; Silica and Silicates, chiefly olivine and labradorite, 61·53. Carbon, oxygen, other constituents, and loss, 1·14.

A paper on the "Action of Salt on Chessylite" then followed by the same author.

At the meeting of the Chemical Society, on December 3rd, the President announced that the Council had that evening adopted a

resolution which would, it was believed, tend to promote scientific investigation. At the present time gentlemen were frequently deterred from the prosecution of interesting investigations by the great expense which they entailed upon the experimenter. To mitigate this difficulty it was now resolved that a certain sum of money not exceeding 50*l.* should be set aside annually as a grant fund in aid of original research. Any claims for grants from this fund which were sent in would be investigated by a committee consisting of four members of council. The Committee recommended that, except in special cases, each single grant should not exceed 10*l.* In accordance with this resolution, gentlemen who wished to prosecute researches were now invited to apply in writing to the Secretary for grants. It was of course to be understood that results obtained with the assistance of such grants must be communicated in the first instance to the Chemical Society.

Two papers followed of great theoretical interest, but too abstruse to bear condensation here. They were "Researches on the Action of Sodium on the Ethers of the Fatty Acids," by Professor Wanklyn, and on some compounds of "Phosphorus with Nitrogen," by Dr. J. H. Gladstone.

On December 17th the only paper was by Dr. J. Emerson Reynolds, "On the Isolation of the Missing Sulphur Urea." The new substance crystallizes in long fine needles or in short thick prisms, in either case belonging to the trimetric system. It is not deliquescent in moderately dry air, is very soluble in water and alcohol, and sparingly so in ether. The solution froths slightly on agitation, has a neutral reaction, and a somewhat bitter taste. Heated with water in a sealed tube for some hours to 140° C., it is reconverted into sulpho-cyanate of ammonium, as may be shown by the iron test. The urea does not give a colour-reaction with the test. Hydrochloric and sulphuric acids effect a similar change. The substance fuses at 156° C. Heated to a higher temperature in a closed tube it evolves sulphide of ammonium, carbonic disulphide and ammonia; the mixture blackens, a yellow oil distils over, and a white mass remains which strongly resembles Liebig's hydromellone. A beautifully-crystallized nitrate of the new urea was prepared by treating the strong aqueous solution with nitric acid of sp. gr. 1·25. No hydrochlorate nor oxalate could be obtained.

At the meeting on January 21st, the first paper read was, "On the Chemical Composition of Canaüba Wax," by Nevil Story Maskelyne, M.A. This wax is the product of a palm—the *Copernicia cerifera*—known to the Brazilians as the Canaüba tree. The glaucous coating which protects the younger leaves contains the wax in the proportion of about 50 grains to the leaf. It is collected and melted into a mass, and in this state constitutes a

pale yellow or greenish body, somewhat harder and less resinous than the wax yielded by the noble palm of the Cordilleras. Its specific gravity is 0·99907, and its melting-point 84° C. The author found that the wax contained no less than one-third of its mass of free wax alcohol—a fact of no little interest in vegetable physiology.

A paper then followed n a subject of great importance to metallurgists, namely, "The Connection between the Mechanical Qualities of Malleable Iron and Steel, and the Amount of Phosphorus they Contain," by Dr. B. H. Paul. It is generally considered that very small quantities of phosphorus in malleable iron and steel are most prejudicial to the quality of the metal. Quite recently an eminent metallurgist had stated as a fact that much less than ·3 per cent. of phosphorus produces a decided and injurious effect on steel. The author had, however, been unable to discover any evidence sufficient to justify such a conclusion, and still less any reasonable explanation of it. He had recently had an opportunity of testing the truth of this conclusion, by determining the phosphorus in some samples of the iron and steel made by the new nitrate of soda process, from British pig-iron known to contain phosphorus. Seven bars of iron and two of steel, made by the Heaton process were examined; their tensile strength and extension had been determined by Mr. Kirkaldy. The iron bars had a tensile strength of from 46,547 to 52,842 lbs. per square inch of area, and an extension, when subjected to this strain, of from 21 to 28·6 per cent. of their length. The two cast-steel bars had tensile strengths of 80,916 and 106,602 lbs., and extended to 3·3 13·7 per cent. of their lengths. In the iron bars the author found ·144 to ·38 per cent of phosphorus (average ·237 per cent.), and in the two steel bars ·24 and ·241 per cent. The author therefore thinks himself justified in asserting that the commonly received opinion on this subject does not always represent the truth. An animated discussion followed the reading of this paper.

On February 4th the members assembled to hear a lecture by Dr. Wallace, on the "Chemistry of Sugar Refining." This was too long to allow of our condensing it into an intelligible abstract. The author commenced by drawing attention to the statistics of the sugar trade in this country, from which it appears that the total value of the imports of sugar during 1868 amounted to 21,000,000*l*. The various stages of selection of the raw sugar, solution, decolourizing the syrup, filtration through charcoal, revivifying the charcoal, and evaporation of the liquor were then fully described. The lecture, which was fully illustrated with tables and diagrams, was followed by an interesting discussion.

6. ENGINEERING—CIVIL AND MECHANICAL.

A GRADUAL change seems to be creeping over the minds of railway engineers, the result of which may not improbably be that some long-acknowledged principles will soon become obsolete. There can be no doubt that the best line of railway, and that which is most cheaply and economically worked, is the one with easiest gradients and longest curves, a perfectly level and straight line being of course the acme of perfection. It is, however, possible that such advantages as to working expenses may be too dearly purchased at the expense of capital, in consequence of the more numerous cuttings, viaducts, and tunnels that would be required, and the greater breadth of land that, in the case of cuttings and viaducts, would have to be purchased; attention is consequently now being directed to the possibility of constructing surface lines, the cost of which would be very small compared with that of our present systems of railways. The Mont Cenis Railway has clearly solved the problem as to the possibility of working up inclines of 1 in 12 and round curves of only two chains radius; and this, it may here be stated, is quite practicable without the aid of the central rail, the use of which is beginning to be seriously doubted. Trains have indeed been worked on the Baltimore and Ohio Railway up inclines of 1 in 10, where coupled engines drew after them a load equal to their own weight; on the Jeffersonville, Madison, and Indianapolis Railway there is an incline of 1 in $16\frac{1}{2}$ of $1\frac{1}{4}$ mile in length; whilst in South Wales some of the mineral lines near Aberdare are regularly worked with locomotives on inclines of 1 in 18. The steeper the incline, the less is the adhesion of the locomotive wheels to the rails, and consequently it is capable of drawing only a lighter load: under similar circumstances also the resistance of a train is considerably increased; thus, on a gradient of about 1 in 150 its resistance is doubled as compared with working on a level, and trebled on a gradient of 1 in 70 or 75. With these data it is easy to calculate upon the probable economy of constructing steep gradient lines, having reference to their less original cost, although probably their working expenses would be increased. On the Metropolitan and St. John's Wood Railway, on its extension to Hampstead, the line will have an incline of 1 in 27 for $\frac{3}{4}$ mile; the Mauritius Railway in its ascent from Port Louis rises 1817 feet to the summit, a distance of 16 miles, in which an aggregate length of 13,526 feet consists of gradients of 1 in 27, and with engines weighing 48 tons, passenger trains of about 50 tons are carried up to the summit at the rate of 12 miles per hour, including stoppages. Mr. Brumlees' proposed Metropolitan and Brighton line would present

no heavy works for construction, the gradients nowhere exceeding 1 in 60, and there being no curve of less than 30 chains radius. Whilst the possibility of working steep gradient lines is thus clearly proved, there can be no doubt with reference to their greater economy in construction; with our present advancement of knowledge, however, a gradient of 1 in 40 is probably the steepest that should be allowed when practicable, and coupled engines only should be employed, of as great weight as can be obtained, and having a good long wheel base.

Under the provisions of an Act of Parliament passed last session, all trains running distances of twenty miles and more, without stopping, must, after the present month (April), be supplied with some sufficient means of intercommunication between passengers and guards. With a view to test the different means for accomplishing this object, some experimental trips were undertaken on the line between York and Scarborough at the latter end of November last, and on the London, Chatham, and Dover Railway, between London and Sevenoaks, during the following week. Three systems have been proposed for the purpose, *viz.*—1. The rope pulls, which is the oldest of them all. 2. The electrical signalling system, of which there are many varieties, and some of them have already been in use for a length of time on the various lines of railways. And 3. The pneumatic system, which, whilst it is the newest, is also in many respects the most efficient. Space will not admit of our giving a detailed description of the several systems that were submitted to trial. The principle of the rope and electric bell systems will probably be well known to most of our readers, and we shall not therefore make further reference to them here. The pneumatic system, being novel, may, however, fairly claim a brief notice. The signalling apparatus consists of a heavy gong upon the engine or tender, and a smaller one in the guard's van. Both these gongs are struck by hammers, which receive direct motion from the train, when a signal is given. When no signal is passed from passengers or others, these hammers are kept away from the gongs, and they are put into gear in the following manner. A tube runs along the whole train, beginning at a pump in the tender, passing from carriage to carriage, and ending in a plug at the back of the train. This pipe, which is worked by the machine, keeps pumping the air out of the pump, and sustains in it a partial vacuum. Underneath those vehicles, which are supplied with gongs, there are shallow cylinders in connection with the vacuum-tube, from which the air being exhausted, their pistons are drawn backwards, and pull thereby the striking portions of the bells out of gear. Over each compartment a T-piece is inserted in the tube, and a plug is fitted into its lower stem so as to keep the tube air-tight. The passengers give signals by pulling out these

plugs, and this, breaking the vacuum, causes the bells to fall into gear.

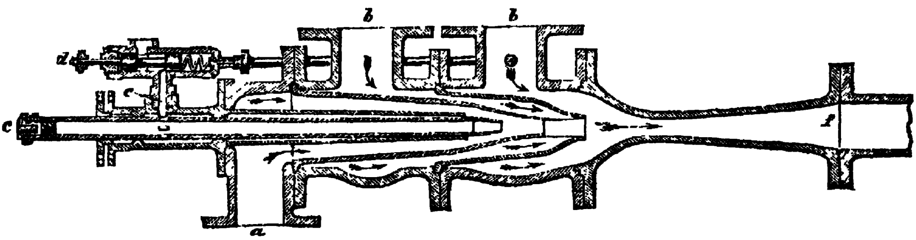
That the pneumatic principle possesses many advantages over the other two, both as to certainty of action and from its non-liability to be tampered with, is beyond a doubt: but the Committee of Railway Managers have nevertheless recommended the rope system, probably on account of its cheapness, and their recommendations have been accepted by the Board of Trade.

The anticipated difficulties attendant upon the location of the great floating-dock recently constructed in this country for Bermuda, in consequence of the insufficient depth of water at the selected site, has led to a proposal by Messrs. Gwynne & Company for the use of a hydraulic dredger for the purpose of increasing the depth of water where the dock is to be finally moored. The principle upon which this dredger is constructed is based upon the fact that sand or other loose earthy material can be freely passed through a centrifugal pump, when mixed with water, in the same manner as the water itself is passed through it. If the sand to be dredged can be well stirred up and the pump be placed under water and close to the sand itself, the rapid removal of the latter is certain; and Messrs. Gwynne's idea is therefore to get their pump to work down at the very bottom, to stir up the sand mechanically, and to conduct all that is so stirred up directly into the pump itself. It would then be driven up a wrought-iron pipe, to the bottom of which the pump is fixed, and delivered in a stream into a barge.

Few people could form any idea, at the first introduction of Giffard's Injector, which has now so generally taken the place of donkey-pumps for feeding boilers, what an important part the principle involved in its construction was likely to play in the economy of steam-engines generally; and even now one would be scarcely justified in assuming that the extent to which it is applicable has been fully realized. Testimony has been amply and repeatedly borne to the correctness of the principles of its construction, but the extent of its economical results is, perhaps, not so widely known as might be. Professor Henry Morton, in the course of a paper recently communicated to the Journal of the Franklin Institute, stated, "That the entire force which passes from the boiler in the issuing steam is returned to it, with the exception of that expended in lifting and injecting the feed-water, and so much as is lost by radiation of heat from the various parts and connections." M. Ch. Combes, Inspector-General and Director of the *Ecole des Mines*, says that the Injector is "without doubt the best of all those hitherto used for feeding boilers, and the best that can be employed, as it is also the most ingenious and simple," and he further adds, "it is theoretically perfect."

The applicability of the Injec or to other than mere feed-water supply has not long been permitted to remain a matter of doubt; and besides other purposes to which it is now applied may be mentioned Messrs. Yarrow and Hedley's plan, by which it has been adapted for clearing out the bilge-water from vessels, for which duty it has been fitted into some steam l inches lately built by that firm. It has also been applied as a steam syphon-pump, for supplying locomotives with water in places where a pump for that purpose is not available. In this case the steam is taken from the boiler of the locomotive to be supplied with water, which, passing through an injector, forces the water up through the stand-pipe.

The most valuable application of the principle as yet attained is, however, to be found in Morton's Ejector Condenser, which invention has recently been brought before the Scottish Institution of Engineers, by Professor W. J. Macquorn Rankine. This ingenious machine will be understood better by reference to the accompanying engraving, in which *a* represents the water-inlet; *b b*, the exhaust



passages; *c*, the regulating spindle; *d*, the self-adjusting steam-valve; *e*, the steam inlet; and *f*, the discharge-pipe. It consists of three concentric tubes terminating in conoidal nozzles, and opening into the hot well or waste-water receptacle by a common and gradually-widening mouth-piece. The central tube is in communication with the water-tank from which the current of injection-water is obtained, while each of the other tubes conveys the exhaust steam from one of the cylinders. As the result of experiments made with one of these condensers, fitted to a pair of steam-engines of 24-horse power collectively, Professor Rankine estimated the saving of power through the dispensing with an air-pump equivalent to the doing away with a resistance of 0·6 lb. per square inch area of steam-pistons; and he found it to be on an average of several experiments just 1-horse power, being about 4 per cent. of the mean indicated horse-power of the engines.

Proceedings of Societies.

The number of Societies meeting in different parts of England and Scotland for the discussion of matters relating to engineering, renders it impossible to do more than briefly allude to some of the

more important papers read before them during the period embraced in this review.

Institution of Civil Engineers.—A paper by Mr. John Frederick Bourne, "On the Roman Rock Lighthouse, Simon's Bay, Cape of Good Hope," is instructive, as pointing out the causes which led to the failure of the original structure. The building consists of a circular tower of cast-iron plates, but it had to be surrounded by a granite casing to a certain height, owing to many of the plates having cracked after its completion. The subject of "Lighthouse Apparatus and Lanterns" was dealt with in two papers by Mr. D. M. Henderson and Mr. J. T. Chance, M.A., in which all the best practice of manufacture at the present day was fully detailed. Of course the manufacture, grinding, and polishing of the glass for the apparatus formed the most important feature in these papers; but the various kinds of lamps were also explained, and, in conclusion, the means adopted for lighting the entrance to Odessa harbour were described. The importance of some improved means for coal-getting has led to the production of two papers by Mr. S. P. Bidder, jun., and Mr. C. J. Chubb, the object of both being a consideration of the means available for getting coal more economically and with greater safety to the miners. A paper "On the Mauritius Railway," by Mr. James R. Mosse, afforded some very valuable information with respect to the working of steep inclines, which subject has been more fully entered into at page 282 of these Chronicles.

Institution of Mechanical Engineers.—At a General Meeting of this Institution at Birmingham on the 5th November last, three papers were read on the following subjects; namely: "On the further Utilisation of the Waste Gas from Blast Furnaces," by Mr. Charles Cochrane, of Dudley; "On an improved Friction Coupling and Break, and its application to Hoists, Windlasses, and Shafting, &c.," by Mr. T. A. Weston, of Birmingham; and "On the Moulding of Toothed Wheels, and an improved Wheel Moulding Machine," by Mr. G. L. Scott, of Manchester. The author of the first-named paper stated that, with the increased capacity of the present large blast furnaces in the Cleveland district, the waste gas given off from the furnace is so far impoverished, both in quantity and quality, that, in order to obtain a uniform supply of gas for heating purposes at the steam-boilers and hot-blast stoves, it is of importance to utilize the whole of the gas given off from the furnace, by preventing the loss of gas hitherto occurring at the times of lowering the closing cone or bell for charging the materials at the top of the furnace; and this, Mr. Cochrane would accomplish by doubly closing the furnace top, the ordinary closing bell and hopper being completely closed in by the addition of an outer cover, containing flap doors, through which the charging materials are filled into the hopper.

Society of Engineers.—The most important papers brought before this Society during the present session have been one on "Modern Gasworks at Home and Abroad," by Mr. Henry Gore; and another "On the Application of Steam to the Cultivation of the Soil," by Mr. Baldwin Latham. Both of these papers contain matters of vast importance at the present time, especially the latter one; but the subjects dealt with are of such a character that it would be impossible to do them justice in the few lines which could be given to them here.

Institution of Engineers in Scotland.—Professor Sir William Thomson has recently introduced before this Institution a new Centrifugal Governor, the principle of which is to employ the increase of centrifugal force produced by increase of speed, by making it the normal pressure for a frictional arrangement directly and simply resisting the rotary motion. A simple modification of Sir W. Thomson's governor allows a plan invented by Professor Fleeming Jenkin to be applied, by which it would be converted into a powerful steam-governor.

LITERATURE.

There are so few works which entirely devote themselves to the subject of Irrigation, that every fresh one must be considered as an important addition to our Engineering literature. Few, if any, of note exist beyond what have resulted from the pens of officers of the Indian Government, and now we have to notice another work emanating from a similar source, entitled 'Irrigation in Southern Europe,'* by Lieutenant C. C. Scott Moncrieff, R.E. This volume was compiled by Lieutenant Scott Moncrieff after a visit to the principal Irrigation works in Southern France, Spain, and Italy, and it will be found to contain much valuable information regarding them which is not to be met with elsewhere. The account of the works in Italy is not so complete as of those in France and Spain, as the author has wisely abstained from going too minutely over the ground so admirably described by the late Captain Baird Smith in his work on 'Italian Irrigation.' In the book now before us, many of the most important headworks, sluices, &c., are illustrated by woodcuts, and the subject of the administration of waters in the different countries is fairly described. In an appendix there is given a translation of the celebrated Spanish Law of Waters, of 3rd August, 1866, under which concessions are granted for the construction of works of irrigation in Spain. A chapter on the Meadow Irrigation of the Mosel Valley is especially interesting, as it gives an account of a system of irrigation not previously described, so far as we are aware, in any work on a similar subject.

'The Railways of India,' † by Captain Edward Davidson,

* E. & F. N. Spon: London, 1868. † Ibid.

R.E., is another work which cannot fail to be acceptable at the present time, containing as it does an account of their rise, progress, and construction. It has been compiled from the records of the India Office, and is stamped with additional authority from the fact of its author having formerly been Deputy Consulting Engineer for Railways to the Government of Bengal.

7. GEOLOGY AND PALÆONTOLOGY.

(Including the Proceedings of the Geological Society, and Notices of Recent Geological Works.)

The Palæontographical Society have just issued their twenty-second annual volume, and, as usual, it is a bulky one; but, though large, it is good. It consists of a series of six parts, all continuations of Monographs now in progress.

(A.) In the first Dr. P. Martin Duncan introduces us to the corals from the White Chalk, the Upper Green-sand, and the Red Chalk of Hunstanton.

Twenty-eight species are illustrated in the nine plates which accompany this part, and many more are enumerated which Edwards and Haime figured and described in the Palæontographical volume (VIII.) for 1853. Such forms as *Trochosmilia*, presenting numerous minor differences of doubtful specific value, have been entered as *varieties* under a common species. This trinomial nomenclature proves exceedingly convenient where the amount of character to be expressed is trivial.

(B.) Mr. Henry Woodward contributes a second part to his Monograph of the fossil *Merostomata*, belonging to the genus *Pterygotus*. The specimens figured are all from the Upper Silurian of Lanarkshire, where they are collected by a Mr. Slimon, who ingeniously turns aside the stream of Logan Water in the summer season, and then excavates the beds which lie beneath. The fossils are preserved (often in a wonderfully perfect state, considering their extreme tenuity) upon the surface of olive-green and grey slates, frequently with all their appendages attached.

Mr. Woodward has pursued the same course as Dr. Duncan, and we find in this part figures and descriptions of four *varieties* of *Pterygotus bilobus*. Six plates are occupied with their illustration. These queer creatures, with their chelate antennæ, large heart-shaped lip-plates, great staring compound eyes, and long fish-like bodies, remind one strongly of larvæ of some aquatic insect. The largest of all the *Pterygoti* is *six feet* in length!

(C.) Again we welcome Mr. Davidson, with his splendid suite of

Silurian "Lamp-shells," or *Brachiopoda;* he is truly the gold-medallist of invertebrate palæontology. His Monographs are altogether *his.* He draws the wood-cuts, he draws those beautiful lithographs; everything is done withhis own hand. Here are fifteen quarto plates, *each of which,* to look at it, must have been a good ten days' work to draw, even after his great experience of the group. How he must love his task to stick by it so manfully year after year! There are more than eighty-eight species and varieties, many of which have a dozen figures in illustration of one species.

(D.) The worthy Professor Phillips adds Part IV. to the British Belemnites, which so many years ago he took under his care. The seven plates (which include three double-sized ones) were executed in Paris, from drawings sent out by Mr. Phillips. They exhibit well the beauty and clearness of French lithography. A great deal, however, depends on the printer. The Professor gives the positions and horizons of twenty species of Belemnites in the strata of the Yorkshire coast, from the Leda-beds to the Lower Lias shale, prepared from his own careful observation, as taught him by his uncle, William Smith, the father of English Geology, the man who was the first to show that strata could be identified by their fossils.

(E.) Professor Owen has added a third part to his Monograph on the Fossil Reptilia of the Kimmeridge Clay, belonging to the genus *Pliosaurus.* In Plates I., II., and III. he gives views of the under or palatal surface of the skull of *Pliosaurus grandis*, and of the upper surface of the lower jaw of the same animal, portion of premaxillary (natural size), jaw, and parts of crania of *Pliosaurus trochanterius,* from the Kimmeridge Clay, Dorsetshire; collected and presented to the British Museum by J. C. Mansel, Esq. The head of *P. grandis* must have been nearly six feet in length, and reminds one (especially the lower jaw) of the cachalot or sperm-whale. Lastly, the Professor figures a very perfect paddle of *Pliosaurus portlandicus,* from the Portland Oolite of the Isle of Portland; also in the British Museum.

(F.) Messrs. Boyd Dawkins and W. A. Sanford add Part III. to their British Pleistocene *Felidæ,* including *Felis spelæa,* Goldf., and *Felis lynx,* Linn. Two single and two double plates are occupied with figures of the limb-bones and pelvic-bones of *F. spelæa,* and one plate with the skull and lower jaw of the Lynx. Of this new cave mammal the authors observe, there is sufficient evidence to prove that the animal was specifically identical with the *Felis* (*lynx*) *borealis* of Norway, or with the variety *F.* (*lynx*) *cervarai* of Siberia. The discovery of the Lynx, a carnivore hitherto unknown in Britain, was made by Dr. Ransom in a fissure that penetrates the Permian Limestone in Pleasley Vale, Derbyshire, termed "The Yew-tree Cave."

The City of Manchester is determined to be to the fore. It is proposed to extend Owen's College into a University, under the title of "Manchester and Owen's College." A large sum (80,000*l.*) is already secured, and the buildings are planned. What will Government do? They have, by the mouth of one of their chief members, intimated that they could do nothing. We are desirous to record that Mr. W. Boyd Dawkins, M.A., F.R.S., of the Geological Survey, whose researches in Fossil Mammalia of the Quaternary Period are so well known, has been appointed to the chair of Natural History at Manchester. Mr. Dawkins, it will be remembered, was the first Burdett-Coutts' Scholar at Oxford.

The Museum of the City of Manchester undoubtedly possesses the finest collection of fossil botanical specimens ever brought together in illustration of the Flora of the Coal Period, by Edward W. Binney, Esq., F.R.S., F.G.S., who has devoted so many years of his life to this branch of geological inquiry.

The Geological Society of Glasgow have just recently issued Fasciculus I. of their quarto Transactions, Palæontological Series. It consists of a Monograph by Mr. Thomas Davidson, F.R.S., "On the Upper Silurian Brachiopoda of the Pentland Hills, and of Lesmahagow, in Lanarkshire;" and contains descriptions of twenty-six species belonging to thirteen genera of Upper Silurian Brachiopoda from the Pentland Hills, and a single species of *Lingula* (*L. minima*), and an uncertain species of *Rhynchonella*, from Lesmahagow. They are illustrated by the author, with his accustomed skill, in three very beautiful plates. This publication, which is started for the express purpose of illustrating Scottish fossils, deserves to be supported by all who take an interest in North British Palæontology.

Mr. A. Keith Johnson, F.R.G.S. of Edinburgh, has published a small quarto Physical Atlas (price 12*s.*), for the use of schools. From the glance we took of it, we were favourably impressed with its neat, clear, and attractive appearance. The maps are coloured to show regions of winds, currents, snow-lines, geological formations, geographical distribution of plants and animals; in fact, on a smaller scale, all that the larger folio Atlas teaches. One map is devoted to illustrations (drawn by A. Geikie, Esq., F.R.S., &c.) of geological features of land; sections of various formations illustrating faults, anticlinal and synclinal curves, glaciers, volcanoes, and all the other phenomena which are treated of in this branch of natural science.

Mr. Scrope, in a communication to the 'Geological Magazine,' vol. v., p. 537, "On the supposed Internal Fluidity of the Earth," observes, "I am gratified to find that the views I entertained and published, more than forty years ago, as to the nature and *modus operandi* of the subterranean agents of change in the earth's crust

are now becoming recognized as true by many—perhaps the majority of geologists—more especially as respects the large part played in these movements by the water contained in the interior heated matter, which eventually, on its superficial cooling, forms the substance of all hypogene rocks. For entertaining this view, I was at that early period subjected to much ridicule, and my arguments generally disregarded."

No better proof can be given of the value now set on the work so long ago performed by this eminent geologist than the fact here referred to, and the writings of Lyell, Phillips, Forbes, and others, testify how much they have themselves learned from this great master.

Professor Owen has an article* on the gigantic Beaver of the Cromer Forest-bed (*Trogontherium Cuvieri*), in which he describes the femur, tibia, calcaneum, and dentition, maintaining its position and distinctive characters, as pointed out by him in 1845.

Mr. Woodward calls attention to the curvature of the tusks in the Mammoth from Ilford, and compares it with the specimens in the British Museum from Siberia and elsewhere, and shows clearly that all the tusks of *E. primigenius* have, in aged individuals, a tendency to curve inwards at their extremities.

Mr. Carruthers describes some new Coniferous fruits † from the Secondary rocks, also a new genus of Cycad from Scarborough.‡

Messrs. Meek and Worthen have published in their 'Palæontology of Illinois' a most interesting series of Articulate Fossils from the Coal-measures of Grundy County, Illinois. Commencing with two new species of *Phyllopoda*, *Ceratiocaris sinuatus*, and *Leaia tricarinata*, they proceed to describe a new and very remarkable form of *Eurypterus* (*E. Mazonensis*), very distinct from those described by Hall, from the State of New York: a new *Limulus* (*Euproops Danæ*), nearly related to *Prestwichia anthrax*: two new Isopods, *Acanthotelson Stimpsoni* and *A. Eveni*. A third form, *Palæocaris typus*, compared by Messrs. Meek and Worthen with *Gampsonyx fimbriatus*, from the Trias, is by them referred to the *Decapoda-Macrura*; but its affinities appear to us far closer with the *Mysidæ* among the *Stomapoda*.

They have found good evidence of *Anthrapalæmon* (a short-tailed lobster), a species of which they name *A. gracilis*. Still more interesting is it to learn that many remains of *Insecta*, *Arachnida*, and *Myriapoda*, of the same age, have been met with. They are—1. *Euphoberia armigera*, a large species of centipede, upwards of 4 inches in length, and preserved in a very

* 'Geol. Mag.,' vol. vi., p. 49.
† Ibid., 1869, January, p. 1, Plates I. and II.
‡ Ibid., 1869, March, p. 97, Plate IV.

perfect state. Another genus of Myriapods (*Xylobius Sigillariæ*) has been described by Dr. Dawson, from the Coal-shales of the South Joggins, Nova Scotia,* and since by Mr. Woodward, from the Coal-fields of Huddersfield and Glasgow.†

A still larger form, named *Euphoberia major*, resembling the fossil from Coalbrook-dale, described by Mr. Salter as *Eurypterus* (*Arthropleura*) *ferox*,‡ has been discovered in the Iron-stone Coal-measure nodules of Grundy County, Illinois.

A very well-preserved Scorpion—named by them *Eoscorpius carbonarius*—is figured and described, which in structure closely resembles the *Scorpio Europæus*, now living, save that the dorsal plates of the thoracic segments appear to be narrower than in the living form. How vast is the measure of the life-time of this species of air-breather of the Coal-period, whose descendants, apparently unchanged in form or organs, are living now in America, Europe, Africa, and Asia, and even Australia, and the fossil remains of which have now been discovered in the Coal-measures of Bohemia and North America. A second form of Scorpion, but very unlike any recent genus—named *Mazonia Woodiana*—is also recorded. Whether it had a long and slender abdomen, like the ordinary *Scorpio*, or—like *Chelifer* and *Thelyphonus*—the abdominal segments are coalesced, cannot readily be determined until more perfect remains have been discovered.

A supplement by Mr. Samuel H. Scudder gives figures and descriptions of eight genera and ten species of fossil insects from the coal of Illinois. As most of these new genera are established on very fragmentary evidence, they should be dealt with leniently; but beyond the fact, which they well establish, that Insect-life was rife in the Coal-period, they do not prove the presence of special families of Insects quite to the satisfaction of the Entomologist. We do not intend, however, by this to disparage the value of Mr. Scudder's labours, as we are well aware of the difficulties he has to contend with in his researches.

The Australian papers have shown, from time to time, that the Legislative Assembly of Victoria was in a very unsettled state of mind upon most questions of internal policy which it was called upon to discuss, and the Ministerial party seemed usually to be in a minority, whichever side happened to be in office. The stoppage of supplies was a favourite method of carrying on political war, the paid officials thereby suffering temporary inconvenience for the sake of their leaders.

But that this learned body should, in its wisdom, decide that the Geological Survey of the Colony of Victoria—conducted thus

* See 'Quart. Journ. Geol. Soc.,' vol. xvi., p. 268.
† See 'Trans. Geol. Soc. Glasgow,' vol. ii., p. 234, Pl. III.
‡ 'Quart. Journ. Geol. Soc.,' vol. xix., p. 84, Fig. 8.

far so ably by Mr. Alfred R. C. Selwyn and his staff—should for the present come to an end, and that these gentlemen should be paid off and sent home to England, seems incredible, did we not learn it from the best authority. Henceforth Mining and Mineral Surveying will alone be considered; but the completion of those beautiful maps—some of which were exhibited by Mr. H. M. Jenkins at Norwich, in illustration of his paper "On the Tertiary Deposits of Victoria"*—will, we fear, now be a far distant event. Strange that the presence of the noble metal, GOLD, should render men so shortsighted—nay, blind—to the best interests of the Colony, as to decide that its geological resources shall remain unmapped and unexplored. Has there arisen a rival geological prophet who objects to Mr. Selwyn's observations on the age of true Auriferous Quartz-reefs because he had a non-auriferous quartz-reef for sale? †

Fossil Botany.—Mr. R. H. Scott, M.A., F.G.S. (who obtained from the Council of the British Association a grant of 100*l.* in aid of the exploration of the Greenland Plant-bed), has just forwarded to the British Museum a series of the leaf-impressions from Atanekerdluk, W. Greenland, collected by E. Whymper, Esq., and described by Dr. Oswald Heer, in his '*Flora fossilis Arctica.*' ‡

Another series of leaf-impressions from the Pipe-clay Bed (Lower Bagshot), Alum Bay, Isle of Wight, collected by W. Stephen Mitchell, M.A., F.G.S., also under a grant from the British Association, have likewise been placed in the British Museum.

The collection of leaves most nearly resembling the Greenland series are from the Miocene Tertiary Fire-clay deposit, overlying the celebrated burning coal-seam on the Mackenzie River, near to the Great Bear Lake, described by the late Sir John Richardson, the leader of the Boat-expedition in search of Sir John Franklin.

Obituary Notices.—All geologists will sympathize with the "Old Silurian Chief" in the loss of Lady Murchison, though she has gone from us in the fulness of years and honours.

Her scientific attainments and abilities as a naturalist were well known, and it has always been Sir Roderick's pleasure to attribute to Lady Murchison's influence his first pursuit of geology as a study, and his subsequent success to her unfailing sympathy and support.

The Irish branch of the Geological Survey of Great Britain has received a severe check, in the loss by death of Mr. George V. Du Noyer, M.R.I.A., F.R.G.S.I., &c., District Surveyor of H. M. Geological Survey in Ireland. His work, commencing as it did

* 'British Association Reports.' Norwich, 1868. Section C.

† See 'Geol. Mag.,' 1866, vol. iii., p. 457 and p. 561.

‡ Die Fossile Flora der Polarländer von Dr. O. Heer. Zurich, 1868, 4to, pp. 192 (50 plates).

under the late General Portlock, extends over nearly thirty years. His pen and pencil have aided in the task of completing forty-eight sheets of the Map of Ireland. He was an admirable draughtsman, and his sketches are well known among geologists and archæologists. He was carried off suddenly by fever, on January 3rd, at Antrim, greatly to the regret of his numerous friends. He leaves a widow and three children unprovided for.

Among the great men who have dropped from the geological ranks during the last year must be mentioned Dr. Hörne's, of the K.K. Mineralien-Cabinet, Vienna. His work on 'The Molluscan Fauna of the Vienna Tertiary Basin' is unrivalled, and the death of its author just as it was arriving at its completion will be deeply regretted.

Principal Forbes, of St. Andrew's, was a man who justly held a high position among men of science. He was a F.R.S. of London and Edinburgh: and his books and papers on 'Heat,' 'The Theory of Glaciers;' 'Travels in the Alps of Savoy;' 'Norway and its Glaciers,' have exercised no little influence on Physical Geology.

The Rev. S. W. King, M.A., F.S.A., F.G.S., of Saxlingham, near Norwich, whose labours in the Crag and Norfolk Forest-bed have resulted in a fine collection of Mammalian remains, now placed in the Jermyn Street Museum.

Nor should we pass over poor old John Ruthven, the author of a geological map of the Lake Country, and the faithful companion and humble friend of Professor Sedgwick in his many geological rambles in the Skiddaw Slate District.

Geology is largely indebted to such native talent in almost every part of our island for some of the best chapters of its history.

Proceedings of the Geological Society.

Since our last Chronicle was written, Mr. Henry M. Jenkins, F.G.S., Assistant Secretary to this Society during the past six years, and Sub-editor of this Journal, having been elected to the post of Secretary and Editor to the Royal Agricultural Society of England, has retired; and Mr. W. S. Dallas (for ten years Curator to the Yorkshire Philosophical Society's Museum, York), has been appointed in his stead. The February number of the Proceedings, however, is edited by Mr. H. M. Jenkins. It contains nine papers published in full, and six in abstract, besides several translations of foreign papers.

Among these papers are several which have been postponed:—(1.) Mr. G. W. Ormerod has a short notice of the probable occurrence of the "Water-stone Beds" of the Keuper (containing pseudomorphous crystals of Chloride of Sodium) in the counties of Somerset and Devon.

(2.) Messrs. J. W. Salter and Henry Hicks contribute descriptions of five new species of Trilobites, from the "Menevian Group," St. David's, belonging to the genera *Conocoryphe* and *Paradoxides*, illustrated by two 8vo plates.

(3.) Mr. Alfred Tylor, F.G.S., describes the Quaternary Gravels of the Aire Valley at Bingley, of the Taff Vale, of the Valley of the Rhonda, the Cave-section (called Bacon Hole) Gower, and the sections at Crayford, Erith, and Salisbury, and he compares the angles of deposition of Gravel-beds concealing the escarpment of the Chalk in these last three localities with the escarpment at Brighton and Sangatte.

The bulk and height of the Quaternary deposits had strengthened the conviction which he expressed in his paper on the Amiens Gravel,* (1) That there was a long period, reaching nearly to the Historical epoch, in which the rainfall was excessive, and which he termed the "Pluvial Period."

(2) That the ice-action (of which there is evidence) was subordinate to the aqueous action.

(3) That the fossiliferous Quaternary deposits have been best preserved where they have been formed in cavities lying between the edge of the bank of a river, estuary, or sea, and an escarpment running parallel with it at no great distance.

(4) That the immediate source of the gravels was the high lands adjoining the rivers, whence they had been washed down by rain, with the assistance of lateral streams, into the lower ground, where they had come in contact with larger quantities of running water, had been mixed with rolled materials, and spread in thick beds over the bottoms and slopes of valleys or the sides of escarpments.

(5) The escarpment is usually concealed under a coating of gravel or loess.

Mr. Tylor argues that with a rainfall such as we now have it would be impossible that such widely-extended gravel-beds could be spread over an extensive area, and reach to a height more than 150 feet above the level of the Thames. It is equally impossible, he thinks, for the present volume of the Thames to have produced fluviatile beds at all equivalent in size to those of the ancient Thames.

That the condition of the beds, which rise above the 50-feet level, points rather to pluvial than to fluvial action.

Mr. Tylor informs us there are no traces of marine remains in the Thames-valley gravels. Assuming that they are of marine origin, gravel-banks are not the safe depositories of organic remains. A walk along the Chesil Bank, or the Shingle-beach at Weybourn

* See 'Quart. Journ. Geol. Soc.,' vol. xxiv., 1868, p. 103.

on the Norfolk coast, would teach this in an hour. As well might we expect to find grains of wheat preserved between millstones.

The gravel that fills a valley is not necessarily the result of the excavation of the valley. It may have been cut out, then submerged beneath the sea—filled to the top with drift—once more re-elevated, and again scooped out, leaving remains of the old drift on its flanks.

To enable the Thames to reach the gravel-beds now more than 150 feet above its waters, we must have a subsidence of land to that extent, which would not only enable the Thames, but the sea itself, to have a hand in rolling them over and remaking them.

We cannot deal here with the great mass of materials brought together in Mr. Tylor's paper, and as we rise from its perusal the feeling is strongly impressed upon us that he is not the "master-mind to whom is reserved the privilege, to whom is given the power, to construct from those fragmentary truths a systematic whole."*

(4.) The other postponed paper, "On Flint Flakes from Carrickfergus and Larne," by G. V. Du Noyer, Esq., will be found noticed in the 'Chronicle of Archæology.'

The contents of the journal proper, that is to say, the papers belonging to the past quarter are:—

(1.) An announcement by Sir Roderick Murchison that the Russian geologists had ascertained that a large tract in Siberia, between the rivers Lena and Jenissei, is composed of Upper Silurian rocks and Carboniferous rocks, containing coal-seams; with rocks of Oolitic and Liassic age, corresponding with those already examined in Russia. It thus appears that the vast, slightly undulating, and, to a great extent, horizontal and unbroken formations, each of which occupies so wide an area in European Russia, are repeated on the eastern side of the Ural Mountains. In this range of mountains only are to be found igneous and erupted rocks.

(2.) Professor Sandberger gives a section of a well at Kissingen through the Zechstein formation, the Bunter and Saliferous beds.

(3.) An abstract only of Mr. Tylor's paper on the 'Formation of Deltas, and on the Evidence and Cause of Great Changes in the Sea-level during the Glacial period.'

This is again a very complex paper, and is presented to the mind like a vast picture, painted by a patient artist who, however, lacked the necessary genius to group his figures and produce the effect he doubtless had in his mind at starting.

A paper treating of the formation of deltas; the parabolic curve of the beds of rivers; raised sea-breaches; the ice-cap at the poles, and reduction of the volume of the sea during the Glacial

* See Article VII., "The Scientific Year," 'Quart. Journ. of Science,' January, 1869, p. 74.

period; coral-reefs in the Pacific; the origin and age of the English Channel—is not to be taken in hand lightly; the paper is a failure, for the reason stated in the other case, the subject has mastered the author.

(4.) Mr. G. M. Browne records an earthquake-wave which appeared at Admiralty Bay, Island of Bequia, on 17th March, and advanced 3 feet in height, a distance from 70 to 350 feet beyond high-water mark. A second smaller wave followed.

(5.) Captain F. W. Hutton sends a note on an extinct Volcano (Nga Tutura) in New Zealand, previously described by Mr. Heaphy.* Captain Hutton thinks the fluid matter that escaped as lava was not connected with any deep-seated matter in the interior, but may have come from rocks 1000 feet below the surface. We are glad to see Mr. David Forbes was present to condemn the rashness of such a statement made at hazard;—the idea of fluid rocks only 1000 feet below the surface is dreadful.

(6.) Mr. Wood Mason calls attention to the discovery of teeth of *Dakosaurus* in the Kimmeridge Clay of Shotover Hill. *Dakosaurus* had, however, previously been found at Potton, near Cambridge, and described by Mr. John F. Walker, B.A., F.G.S., in the 'Annals and Mag. Nat. Hist.,' 1866.

(7.) Dr. Duncan's paper on the Test of *Amphidetus* was withdrawn.

(8.) Mr. Bauerman's "Geological Reconnaissance in Arabia Petræa" is, we trust, the first only of a series of good papers on this interesting country. Hills of gravel-topped alluvium, gravel-plains, gently swelling or terraced plains of sand, a kind of oolite made up apparently of rolled fragments of shells, dipping sea-wards; blue shaly clays with gypsum; granular massive gypsum, or alabaster; cliffs of calcareous grit-stone finely stratified; white chalky limestone; a bluish grey or white crystalline (Tertiary) limestone, and a soft limestone (these last bearing Nummulites), a series (600 feet thick) of Lower Cretaceous rocks, and of dark-red soft sandstone, with marly partings (like the Lower New Red Sandstone about Chester), these are the principal formations met with.

Old mines were observed in several places in a bed of iron and manganese, and remains of copper-works of considerable extent. Turquoise-mining has been carried on by the late Major Macdonald, and subsequently by a Frenchman with more or less success. The implements of still earlier miners, discovered by Mr. Bauerman, are recorded in the Chronicle of Prehistoric Archæology.

(9.) Dr. Le Neve Foster and Mr. Bauerman have a joint note on the occurrence of Celestine in the Nummulitic Limestone of Egypt.

The Celestine occurs not only in detached crystals, but also,

* 'Quart. Journ. Geol. Soc.,' 1859.

filling the interior of fossil shells, especially the chambers of *Nautili*.

(10.) Dr. Duncan adds a note on the Echinodermata, Bivalve Mollusca, &c., from the Cretaceous rocks of Sinai. The list shows that thirteen out of twenty-four species are common to the North African and Sinaitic Cretaceous rocks, and that eight others are well-known European forms.

(11.) M. Charles Martins describes the evidence on which he concludes that a Glacier during the Quarternary Period occupied the Valley of Palhères, in the Lozère.

At the Annual General Meeting of the Society, the President (Professor T. H. Huxley, LL.D., F.R.S.), presented the Wollaston Gold Medal to Henry Clifton Sorby, Esq., F.R.S., as a mark of the Society's appreciation of his researches into the structure of rocks, minerals, and meteorites, and the investigation of the phenomena of Slaty Cleavage. He also handed the balance of the proceeds of the Wollaston Donation Fund to William Carruthers, Esq., F.L.S., F.G.S. of the British Museum, in aid of his researches in Fossil Botany, in which branch of study he has already added so much to our knowledge.

8. METEOROLOGY.

The Pilot Charts for the Atlantic, alluded to in our last number, are the first instalment of a systematic series of representations of the physical phenomena of the ocean which are promised by the Hydrographic Office of the Admiralty. In the advertisement prefixed to the work, Captain Richards explains that, from their very nature, these charts cannot be offered with the same confidence or authority as the charts on which depend the safety of navigation. They are in fact only intended to furnish hints to the seaman in shaping his course. All available sources of information, both British and foreign, have been consulted in their preparation, so that the charts may be fairly considered as a record of the present extent of our knowledge of ocean meteorology, in the particulars of which they treat.

They consist of four wind-charts, corresponding to the different seasons, a current chart and an ice chart of the Southern Hemisphere.

On the wind-charts the percentages of prevailing winds are represented by means of stars, for spaces varying in size from ten-degree squares in the heart of the S.E. trade-wind to two-degree squares off Cape Horn. The number of gales from each point per month is also given, and on the coasts some useful practical remarks

as to the weather which may be expected there. Other notices concerning meteorological phenomena generally are to be found in the form of notes, while the limits of certain districts, such as those of the trade-winds, the equatorial rainfall, &c., are laid down by curves. These wind-charts are most useful of their kind, and far more intelligible than those which have formerly appeared in this country and the United States; but in certain parts of the ocean more specific information as to both date and place is undoubtedly required. Though for the S.E. trade the means of ten-degree squares for three months may suffice amply, we require for other parts at the least monthly means for much smaller areas, such as those given on Adm. Chabanne's charts for the coast of Brazil, published by the Département de la Marine in Paris in 1861.

The current chart gives a graphical representation of the general course of the chief currents throughout the year, with notes showing how their set on each coast is affected either by the winds or by other disturbing causes. The course of the principal isothermal lines of surface temperature is also given, as well as entries of the most remarkable deep-sea soundings.

In the atlas is included the ice chart of the Southern Hemisphere, which appeared about three years ago. The urgent necessity for such a chart became very obvious when the introduction of great circle sailing brought prominently before the notice of navigators the dangers to be experienced from ice in high southern latitudes.

The whole atlas is a most useful work, and shows on its face the care and labour which have been spent on its compilation; we shall be glad to see the similar series for the Indian and Pacific Oceans.

With reference to the subject of sea-temperature, and more especially of that prevailing at great depths, the report recently submitted to the Royal Society by Dr. Carpenter and Dr. Wyville Thomson is of great interest and importance. These gentlemen wishing to test, by direct experiment, the truth of the assertions made by the late Edward Forbes, as to the depth in the sea at which organic life ceased to exist, and on which statements considerable doubt had been thrown by the soundings made by M'Clintock, in the 'Bulldog,' and by others, obtained the use of H.M.S. 'Lightning,' and proceeded last autumn on a cruise off the west coast of Scotland. The results as to the precise biological question above referred to, which were obtained by the expedition, do not belong to the present subject, but the observations on temperatures at great depths merit particular notice.

It is well known that an idea has been nearly universally accepted, that the sea-bottom at great depths was covered by a stratum of water possessing a temperature of $39^{\circ}\cdot5$. In low latitudes this stratum was said to be covered by water warmer than its

own; in high, by water colder. This view carried with it the support of so eminent a man as Sir J. Herschel, in his various writings on Meteorology and Physical Geography. This temperature of 39°·5 is, however, that of the maximum density of *fresh* water; whereas the behaviour of saline solutions is very different from that of fresh water under similar circumstances. The direct experiments of Despretz on sea water, brought from the South Pacific by Freycinet, established beyond a doubt the following facts:—

The density of the water at 68° F. was 1·0273 under ordinary circumstances, *i. e.* if slightly agitated, it froze at 27°·4; but if it were cooled very carefully, a maximum density was reached at 25°·4.

Subsequent to Despretz's experiments, which were published in the 'Comptes Rendus' for 1837, Sir J. Ross, in his Antarctic Expedition, tested the temperature at various depths, but failed to ascertain the existence of any water at a lower temperature than 39°. However, long anterior to this date, General Sabine had obtained evidence in the Arctic regions of the existence of water at a temperature much below 32°, at depths of 700 fathoms or so. Recent observations by Captain Shortland in the Indian Ocean have led to similar results.

The instruments, however, which have hitherto been used were eminently untrustworthy, the indices, especially of the maximum thermometer, being extremely liable to displacement by a jar, so that frequently a temperature was recorded as maximum which was not as high as the surface temperature. Such a fact as this throws discredit on the observations of minimum temperature made by the same instrument. In addition, these thermometers are liable to be deranged if they are even laid in a horizontal position; so what are we to expect when the sounding line brings them up, as it sometimes does, in a reversed position! However, during the past year, the Hydrographic Office has paid particular attention to the improvement of these thermometers, and the 'Lightning' was accordingly furnished with the new pattern instruments, several of which were brought home in good order, so that the results furnished by them merit especial credit.

The chief fact as to temperature ascertained by the expedition is the existence, over a certain area between the Faroe and Orkney Islands, of water possessing a temperature of about 32° at a depth of 500 fathoms, while in other soundings taken in the adjacent districts, the temperature at equal or even greater depths was persistently registered above 45°. On one occasion, within the cold area, bottom was found at 140 fathoms, and the minimum temperature recorded was 41°·7, showing the decrease in temperature to be progressive with the depth. Each of the areas was characterized by the presence of special organisms, leading to the

conclusion that the distribution of animal life is more closely related to the *temperature* than to the *depth* of the sea. However, the results of the sixteen soundings made by this expedition must be considered as merely tentative; and we can only hope that the present Board of Admiralty will give as cordial countenance to the inquiry as their predecessors did, now that it has been shown, as Dr. Carpenter observes, "that within a short distance of the northern coast of Scotland an opportunity is presented for determining with great precision the physical conditions of two opposing currents with a difference of temperature of at least 15°." This determination is not, by any means, as simple a matter as it may seem. Deep-sea sounding is no child's play, and when we have to ascertain thereby not only the depth of the sea, but the existence, the course, the limits, and the physical conditions of submarine currents, the problem becomes one of extreme difficulty; and we shall look with great interest to the attempts made to effect its solution.

While we are on the subject of ocean currents, a book recently published by Mr. Jordan,* calls for special notice. In this work the author proceeds, as he says himself:—"Firstly, by theoretical deduction, to demonstrate hypothetically the action of *vis inertiæ*.

"Secondly, by practical investigation, to ascertain whether or not there exist in the ocean such movements as may, in the first part, be demonstrated to be the natural result of the action of *vis inertiæ*."

In the first book the theoretical effect of the principle, as brought into action by the rotation of the earth on its axis, and by its annual orbital motion, is examined. In this portion, though we may allow the truth of a good deal that Mr. Jordan says, we must say that more actual proofs are required before we can admit the existence of perpendicular and inclined circulations in the ocean, such as he supposes to exist. We are hardly prepared to attribute the circumstance that the tendency of an equatorial current of air is to lower, while that of a polar is to raise, barometrical readings, to the fact that while the former is, in virtue of its nature, an ascending current, the latter is a descending one.

The question of ascending and descending currents requires investigation, but we are decidedly disposed to believe that not unfrequently the south-west wind descends to the earth, *e. g.* at the edge of the trade winds, while the north-east wind at times rises from it.

Some of the diagrams of ocean circulation given by the author

* 'A Treatise on the Action of Vis Inertiæ in the Ocean, with Remarks on the Abstract Nature of the Forces of Vis Inertiæ and Gravitation, and a new Theory of the Tides.' By W. Leighton Jordan, F.R.G.S. London: Longmans.

are extremely pretty as representations of osculating curves, but we want more positive facts in support of them before they can be accepted as final explanations.

In Book II. we have the investigation of ocean currents, which are all attributed to the action of *vis inertiæ*, but here the author's hobby runs away with him a little, for at page 105 he says:—

"Why, if the trade-winds result from the heating action of the sun, they should continue to blow at night just as in the daytime, is, it appears to me, not easy to understand."

The action of a heated surface in causing an ascending current of air does not cease at nightfall over large areas like Central Asia, as it does in the case of small islands, where the diurnal alternation of land and sea breezes holds good. An extensive circulation of air, once set going, is not easily diverted into other channels. However, the monsoons and coast winds in general offer a serious objection to Mr. Jordan's views, and are in favour of the interpretation generally received.

Book III. treats of *vis inertiæ* and gravitation; and here at the outset we are met by a new principle—*evanescence*. "In this term comprehending the unknown laws which control matter throughout its existence, and by it inferring that matter has not always existed, and that in course of time it will cease to exist; presuming, of course, that it is only reasonable to suppose that something immaterial existed from which it had its origin, and that when it has run its course and ceased to exist something immaterial evolved from it will exist after it."

Not having seen the author's other work, 'The Elements,' we are at present unable to understand how he proposes to create matter.

The chapter on tides is happier, and the explanation of the retardation of spring and neap tides respectively for a day or two after the moon's changes have taken place is clear and intelligible.

There is one very serious objection to the book as a whole—the style is confused to the last degree, and it is often necessary to read a page two or three times to make sure that you have caught the author's meaning. When he is stating two alternatives, each is given at full length, so that the occasional use of the words, "and *vice versâ*" would have reduced the size of the book by at least twenty pages, and made it much more intelligible.

In the last Chronicle we referred briefly to the synoptic charts of the Indian Ocean, submitted to the British Association by Mr. Meldrum, Secretary of the Meteorological Society of the Mauritius. These charts present some features of great interest when compared with those issued by Le Verrier for the North Atlantic. Mr. Meldrum's long experience of the weather of those seas renders whatever he may say about it well worthy of attention. However,

in these charts he allows the facts to speak for themselves, not drawing isobaric lines unless their course is fully justified by observations. In every case he enters these latter, pure and simple, omitting the barometrical readings, unless he is thoroughly satisfied as to their correctness: accordingly the charts are chiefly representations of wind and weather. The region with which he has to deal is in some respects easier to manage than that of the North Atlantic, because the areas of the monsoons and other prevailing winds are clearly and sharply defined. In some of them Mr. Meldrum has been able to trace cyclones from their origin at the southern edge of the N.W. monsoon, rotating *with* the hands of a watch; while in high southern latitudes he finds the wind at times moving in the opposite direction round a relative barometrical maximum, forming what Galton calls "Anticyclones." Both these motions are of course opposite to what obtains in the Northern Hemisphere. It is sincerely to be hoped that Mr. Meldrum will carry out his intention of issuing these charts for a considerable period of time, so that weather may be traced consecutively from day to day. We should say that the *time* on the charts is noon for the meridian of 60° E., being the central meridian of the charts.

The most important paper which has appeared of late in the journals of our home Societies has been one of which the subject is somewhat cognate to what has just been described—we mean Mr. Buchan's investigation of some American storms, published in the October number of the 'Journal of the Scottish Meteorological Society.' In this paper, which is illustrated by three charts for March 16, 18, and 19, 1861, we are presented, not only with the atmospherical conditions of half the Northern Hemisphere, north of the parallel of 30° N., but also with the tracks of certain storms, some of which he has traced across the Atlantic Ocean. The charts have precisely the faults which have been avoided in those just noticed, *viz.* that the isobaric lines are drawn with a free hand and on insufficient data, so that the attention is distracted from the observations themselves to the interpretation given of them by the author of the paper. If the line of inquiry thus undertaken by Mr. Buchan be followed out by him, and the fact that storms do occasionally cross the Atlantic be placed beyond the possibility of cavil, a great step will have been made; but in the theoretical explanation given of the storms we regret to find a vagueness of reasoning, which is a very serious defect, and leads us to doubt the probability of his proving his case satisfactorily. Thus he reiterates the old idea that the latent heat set free by condensation of aqueous vapour has a material effect in reducing atmospherical pressure, without justifying the statement by any calculation whatever. He also adheres to the belief that the rotation of the air in a cyclone is caused by the diurnal rotation of the earth, whereas the opposite to this has been

shown to be the case. In a cyclone in the Northern Hemisphere, on one side, the wind in its motion round the central area "backs" from south towards south-east, and on the other side it backs from north towards north-west; whereas the effect of the earth's rotation on a southerly wind flowing pole-wards is to give it westing, in consequence of its change of latitude, and the wind therefore "veers" towards south-west and west, forming not a cyclone but an anti-cyclone.

This carelessness of language is most unfortunate, as it mars much of the valuable work Mr. Buchan is doing. In one of his later papers he asserts that the air is composed of oxygen and hydrogen, while in the last edition of his 'Handy Book of Meteorology' he proposes that each missionary should be instructed in meteorology, in order to issue storm warnings for the South Sea Islanders, "and legitimately increase his influence over them!"

9. MINERALOGY.

Considering the extensive employment of that large class of ornamental stones grouped together under the general name of *Agate*, it is surprising how little is commonly known in this country as to the source whence they are obtained, and the manner in which they are worked. A small district at the southern foot of the Hundsrück, in Western Germany, has for more than four centuries been almost exclusively the seat of the agate trade, and at the present time upwards of 3000 of the inhabitants gain a livelihood by this peculiar branch of industry. Full information on all that relates to the subject of agates has lately been published by Herr Lange, who writes from the little town of Idar, situated in the very centre of the agate works.*

Agates usually occur in the form of amygdaloidal nodules, of greater or less size, embedded in a dark-coloured trap-rock or melaphyre. Many are the theories that have been advanced to explain the origin of these nodules, since the time when it was first suggested that they were petrified melons! At the present day it is generally supposed that the cavities now filled with agate were produced by the disengagement of gas or steam when the melaphyre was in a viscous condition. After the solidification of the lava-like

is a question still open to discussion. Some suppose that the solution transuded through the walls of the entire cavity, whilst others argue in favour of a local infiltration confined to special inlets, which are often exposed on cutting a section of an agate. Probably both theories may be advantageously combined; the deposit of "green-earth" which commonly lines the smaller cavities being due to a general percolation through the walls, whilst the solution of silica was introduced through definite channels or inlets of infiltration. It is difficult, however, with either theory to explain satisfactorily the formation of a regular succession of concentric layers lining the internal walls of a cavity, and not deposited simply upon its floor; whilst it is still more difficult to understand the conditions under which concentric layers were deposited at one time and horizontal layers at another—conditions which must have obtained during the formation of many of the so-called "Brazilian agates," which exhibit both deposits in the same stone. According to Reusch, the successive layers have been deposited from a solution which was alternately forced into and expelled from the cavities by the action of intermittent thermal springs. A modification of this theory is that adopted by our author. He supposes that the solution, after having deposited gelatinous silica in the cavity, was heated to its boiling point, and that the elastic force of the steam thus generated would press the siliceous jelly equally against all sides of the cavity, so as to produce a layer of uniform thickness throughout. The compressed steam would then slowly make its exit by perforating a passage through the successive layers; but if this outlet became sufficiently large, the steam might escape before acquiring sufficient tension to keep the gelatinous mass distended against the walls, and hence the silica, left to the force of gravity, would be deposited in horizontal layers upon the floor. In this way the author attempts to explain the alternation of concentric and horizontal deposits in the same cavity—a point which has hitherto been a standing enigma in all theories on the formation of agates.

The occurrence of beautiful agates in the melaphyre of the Saarbruck coal-field led at an early period to the localization of the agate trade in the neighbourhood of Oberstein and Idar. Although for many years past no agates have been quarried in that locality, all the fine stones being imported from Uruguay, the trade of cutting and polishing still remains active, and at the present time there are 183 mills in the district, carrying 724 grinding stones; each double mill being reckoned as two single ones.

In the Chronicles of Mineralogy for July last, attention was directed to a remarkable shower of meteorites near Pultusk, in Poland.* Many thousands, not to say hundreds of thousands, of

* 'Quart. Journ. of Science,' vol. v., p. 419.

these stones fell within a very limited area, and thus ample opportunity was furnished of collecting specimens. A large number of these have lately been examined by Vom Rath, who shows that they consist of about 86 per cent. of silicates—probably Olivine and Shepardite—associated with 10 per cent. of nickeliferous iron, and nearly 4 per cent. of magnetic pyrites, together with a small percentage of chrome iron-ore.*

Although copper-pyrites is the most widely diffused of our copper-ores, it is by no means common to meet with well-defined crystals; and hence observations upon its crystalline forms are of much value. Formerly the mineral was referred to the cubic system, but in 1822 Haidinger showed, by measurement of the fundamental octohedron, that it must be removed to the tetragonal system. Herr Sadebeck, of Berlin, has paid considerable attention to the crystallography of this species, and has recently published the results of his study.† He first separates the two opposite tetrahedra, or hemihedral forms of the tetragonal octohedron, distinguishing them as tetrahedra of the first and second orders respectively. He then discusses the laws according to which twins are combined—a point of considerable interest, since twins of this mineral are much more common than simple crystals. Finally, he gives the characters of typical forms from different localities, and shows that these are in many cases so peculiar, as to enable the mineralogist, by a study of form alone, to refer a given crystal to its original locality.

Every collector must be familar with the beautiful crystals of limpid quartz, which, in company with calcareous spar, line many of the drusy cavities in the famous snow-white marble quarried at Carrara. More than 200 specimens from these quarries have been examined by Dr. Scharff, who has lately published a paper on their irregularities of growth.‡ He shows that the crystals, although apparently simple, are in many cases formed by the union of several individuals, by which the aggregate crystals possess an apparent rhombohedral cleavage. The two opposite rhombohedra, forming together the six-sided pyramid that caps each crystal, are often developed to a very unequal extent; the faces of the positive rhombohedron being enlarged at the expense of the corresponding negative form.

Dioptase—a beautiful and rare silicate of copper found in the wilds of the Kirghese Steppes, and so strongly resembling the emerald as occasionally to be mistaken for that gem—has recently

* Leonhard und Geinitz's 'Neues Jahrbuch.' 1869. Heft I., p. 80.

† Zeitschrift der deutschen geologischen Gesellschaft. Band xx. Heft III., p. 395.

‡ Leonhard und Geinitz's 'Jahrbuch für Mineralogie,' u.s.w. 1868. Heft VII., p. 822.

been subjected to chemical examination by Herr Rammelsberg.* From the behaviour of the mineral when exposed to heat, he infers that the molecule of water which it contains is present in a state of true chemical combination, and not simply as water of crystallization. The formula of dioptase thus becomes

$$H_2\ Cu\ Si\ O_4$$

and the mineral is therefore isomorphous with the two corresponding hexagonal silicates, Willemite and Phenakite, the former containing $Zn_2\ Si\ O_4$, and the latter $Be_2\ Si\ O_4$.

Some time ago we had occasion to notice the discovery of a native hydrous arseniate of zinc from Chile, described under the name of *Adamite.*† This species has lately been obtained by Messrs. Gory and Boutigny from a small copper mine worked in the Keuper sandstone of Cape Garonne in the Dépt. du Var. The French adamite occurs in the form of lenticular crystals or thin plates on the walls of fissures traversing a quartzose rock, and is associated with the two arseniates, olivenite and cobalt bloom; the latter imparts a reddish tint to many of the crystals, which otherwise present a greyish colour.‡

In compliment to Professor Laxmann, the Siberian traveller, the name of *Laxmannite* is proposed by M. A. E. Nordenskjöld for a new mineral discovered at Beresow, in Siberia.§ It appears to be a chromate and phosphate of lead and copper; its chemical composition being represented by the following formula, where $RO = PbO + Cu\ O$:

$$3\ (\tfrac{2}{3}\ RO,\ \tfrac{1}{3}\ HO)\ PO_5 + 2\ (3\ RO,\ 2\ Cr\ O_3).$$

The component minerals of some of our Cornish granites have lately been examined by the Rev. Dr. Haughton.‖ He finds that these rocks contain two felspars and two micas; the felspars, he refers to the species orthoclase and albite, and the micas to lepidolite and lepidomelane. Dr. Haughton supposes that these constituents are common to all the granites of Cornwall and Devon, which thus bear a close resemblance in mineralogical composition to the granites of Leinster and Mourne.

Analyses of two titaniferous magnetites from Norway have been published by Mr. David Forbes;¶ and a large number of chrome iron-ores have been chemically examined by M. J. Clouet, whose memoir on these minerals is supplemented by a note in which

* Zeitschrift d. deutsch. geolog. Gesellsch. Bd. xx., p. 536.
† 'Quart. Journ. Science,' vol. iii., p. 427.
‡ 'Comptes Rendus,' Dec. 7, 1868, p. 1124. 'Geol. Mag.,' Feb., 1869, p. 79.
§ 'Journal für praktische Chemie.' Band cv., No. 22, p. 335.
‖ 'Proc. Royal Society,' vol. xvii., No. 108, p. 209.
¶ 'Chemical News,' Dec. 11, 1868, p. 275.

M. E. Peligot points out the many relations that subsist between chrome iron-ore and magnetic oxide of iron.*

Von Lasaulx announces the discovery of tridymite in trachytic nodules occurring in a kind of hornstone rock from Alleret, in the department of Haute-Loire.†

One of Dr. Blum's valuable contributions to the study of pseudomorphism has recently appeared,‡ and contains the results of his observations on materials that have accumulated since his last publication.

Several new Swedish minerals have been described by C. W. Blomstrand from near Westanå, in Schonen.§ Most of these are hydrous phosphates of alumina, more or less akin to Wavellite. They have received the names of *Berlinite*, *Trolleite*, *Augelite*, *Attakolite*, and *Kirrolite*. A hydrous silicate of alumina, named *Westanite*, has the following composition:—

$$2\,Al_2\,O_3\,.\,3\,Si\,O_2 + HO.$$

Dr. Petersen of Darmstadt applies the name of *Hydrotachylyte* to an amorphous mineral found in the basalt of Rossdorf, near Darmstadt.‖ It is a hydrous silicate containing alumina, sesquioxide of iron, potash, soda, magnesia, lime, and the protoxides of iron and manganese. A portion of the silica is apparently replaced by titanic acid.

10. MINING, METALLURGY, AND RECENT LITERATURE.

Mining.

The Stannary Court of Cornwall and Devonshire is nearly the oldest—if not actually the oldest—court existing in this country, with almost all its original constitution preserved, and with its forms unaltered. Dating from the time of John, who granted a charter of special privileges to the tinners, and taking a more perfect organization in the third year of Edward I., the Court of the Stannaries has remained until now without any special alteration. Carew tells us that "upon suit made to Edmonde, Earl of Cornwale, sonne to Richard, King of the Romans, they obtained from him a charter with sundrie privileges; amongst which it was granted them to keep a court and hold plea of all actions (life, lymme, and land excepted), in consideration whereof the said lords

* 'Annales de Chimie et de Physique,' Jan., 1869, pp. 90, 100.
† Leonhard und Geinitz's 'Jahrbuch.' 1869. Heft I., p. 67.
‡ Leonhard und Geinitz's 'Jahrbuch.' 1868. Heft VII., p. 805.
§ 'Journal für praktische Chimie.' Bd. cv., No. 22, p. 337.
‖ Leonhard u. Geinitz's 'Jahrbuch,' 1869, p. 32.

accorded to pay the Earl a halfpenny for every pound of tynne which should be wrought," &c. At the head of this court is a Lord Warden—now the Duke of Cornwall—who appoints his Vice-Warden, by whom the courts are held.

This ancient Mining Court is now about to undergo—perhaps not too soon—material modification; and on the evening of Friday, the 26th February, Mr. John St. Aubyn, one of the members of Parliament for West Cornwall, obtained leave to introduce a bill to the House of Commons "*for amending the law relating to Mining partnerships within the Stannaries of Devon and Cornwall and to the Court of the Vice-Warden of the Stannaries.*" This involves so important a change in the laws which relate to mining in the West of England, that, although this Journal is not the place for discussing the questions at issue, it appears necessary to record the intended alterations in our mining chronicles.

From time to time various suggestions have been made relative to the organization of some system by which a provision might be secured for the widows and children of such coal-miners as may perish in the course of their labours. A plan of colliery insurance has been more than once proposed, and there is but little doubt that it would have been long since established had the period been a more auspicious one for commercial speculation.

The project for organizing a Colliery Insurance Company, to embrace a provision for the survivors of those killed in colliery accidents, and to reimburse the colliery proprietor or worker for any loss accruing to his property, is again exciting attention. A letter has been published by Mr. Stephen Sleigh, of Austin Friars, which clearly shows the practicability of such a system of insurance. We learn from this letter that the value of the colliery property of Great Britain is estimated at 70,000,000*l.* sterling. The production of coal is at present 104,000,000 tons per annum, and in obtaining this, on the average of ten years, 1000 lives are lost in each year. It appears that 2*d.* per week per man would produce a fund from which 100*l.* could be given to the widows and children of the deceased collier; and that a very small premium, varying of course with the district, would secure the insurer from any serious loss to his property. As active measures are about to be taken to establish this most important principle, we content ourselves at present by directing attention to the movement.

In the House of Commons, on Thursday, February 25th, Mr. Greene asked the Secretary of State for the Home Department whether it was the intention of the Government to introduce any measure for the further prevention of accidents in coal-pits. He elicited the reply—that a measure on the subject was being prepared and would shortly be laid before the House. Mr. Kinnaird inquired if the Government intended to bring in a bill for the

better regulation of metalliferous mines in accordance with the recommendations of the Mines Commission. The answer given by Mr. Knatchbull-Hugessen was curiously evasive; no bill was in preparation, but he hoped that legislation would not be long postponed. It is now nearly five years since the Commission, of which Lord Kinnaird was the President, made its report. In that report the Commissioners most strongly urged the necessity of some prompt legislative enactments, by which the more perfect working of the copper and tin mines might be secured and the lives of the men preserved. Nothing has, however, as yet been done, and during the long-continued depression of mining, things have been allowed to become gradually worse than they were when the Commission examined them. The whole system of working our copper and tin mines is so bad, that no hope can be indulged in of their improvement until the Legislature steps in, and by some well-considered measure protects alike the miner and the shareholder from the present destructive system.

Coal in the Colorado district is a matter of great importance. According to the 'Denver News,' General Pierce stated to the Board of Trade that besides the bed of 31 inches, discovered near Fort Dupton, on the Platte, there were also two beds on the Cache-la-Poudre. One of these beds was 4 feet thick, and the other about 18 inches. The 'Salina Herald' says that in digging a well on the east side of the Smoky Hill River—less than two miles from town—a bed of good bituminous coal, 18 inches thick and about 20 feet below the surface was cut through.

Coal-mining in France has, during the past year, been particularly active. This will be seen from the following statement of the production during each of the last six years:—

	Tons (Statute).		Tons (Statute).
1863	10,516,752	1866	11,807,142
1864	11,001,249	1867	11,975,161
1865	11,785,714	1868	12,345,000

The collieries of Belgium have not exhibited the same progressive increase. From the report of Mr. F. Jocham, Director of Mines in the province of Hainault (which is the last published authority on the production of coal in Belgium, we learn that to the end of 1867 the production was as follows:—

	1865.	1866.	1867.
Hainault	9,206,058	9,831,424	9,595,280
Namur	305,754	358,687	389,586
Liége	2,328,911	2,564,551	2,770,956
Total of the Kingdom in Metrical Tons	11,840,723	12,754,662	12,755,822

The copper mines of Africa have of late years been attracting

considerable attention. The copper lodes in the Insizwa Mountain, about 12 miles from the southern boundary of Natal, are remarkable. Some comparatively small workings have been carried on about 80 miles from Port St. John. The deposit here is described as about 18 feet thick by $2\frac{1}{2}$ feet in depth. From this description it is evidently not a *vein*, but a *bed*. This is clearly in a state of decomposition, since it is said the ore is replaced by a yellow ochreous deposit (*gossan* of miners) containing nodules of very pure carbonate of copper or malachite, varying in size from a pea to masses of 10 or 15 lbs. weight. Some miners from D'Urban penetrated deeper into the mountain, and again found a similar deposit. Portions of considerable masses have been found to contain as much as 56 per cent. of metal, the average, however, being from 30 to 40 per cent. Silver was found to the extent of 5·30 ounces to the ton of copper, and a trace of gold was detected.

Chromium is stated to have been discovered in large quantities in Maryland and Pennsylvania. Chromate of iron of fine quality has also been found in Victoria. We understand samples of this mineral and antimonial ores of good quality have been shipped to this country with a view to determining their real commercial value.

In a cave in the mountain of Galenstock, which it is well known separates the cantons of Berne and Urich, a valuable deposit of topaz has been recently found.

Tin mines in Siam are, on the authority of the 'Journal of the Society of Arts,' about to be worked. We quote the paragraph:—

"Another tin district is about to be opened at the Isthmus of Kra. The immense value of the tin-workings at Junk, Ceylon, or Phuket, supposed to be not less than 150,000 tons per annum, has incited a Chinese merchant to propose the active development of the Kra Mines, and as tin is supposed to abound along the whole range of the Malay peninsula there are many who believe in his success. He is to have the government of the district to enable him to carry out his designs. The river of Kra is the southern boundary between British Burmah and Siam."

Seeing that the annual production of tin is as follows:—

	Tons.
England	7,296
Banca	4,260
Billeton	1,900
Other parts	3,000
Total	16,456

—the 150,000 tons said to be produced at Junk is an evident absurdity. During the past year the Chinese merchants have been the largest buyers of British and Dutch tin, to which circumstance

we owe the rapid rise in the price of tin which has lately taken place. This proves that they have not any great expectations of very considerable production of this valuable metal nearer home.

The prominence which has been given to technical education has led to a proposal to found a Professorship of Mining in the University of Glasgow; and a deputation has been in communication with Professors Ramsay and Huxley, of the Royal School of Mines, on the question of establishing a mining school in Wales. The experiments made already in Glasgow, at Bristol, and by Sir Charles Lemon, and others, in Cornwall, should teach the lesson that it is quite impossible for the miner to attend any fixed central school. The only practical and useful system of imparting instruction to the miners is that—adopted with great success by the Miners' Association of Cornwall and Devonshire, and by Mr. Daglish, in the neighbourhood of Seaham,—of sending the teacher to the miner, and giving him the advantages of a school of mines in the very midst of the district in which he labours.

GOLD.—The Nova Scotia gold-fields have produced during the past three years as follows:—

	Ounces.
1866	25,204
1867	27,314
1868	20,733

The production of the quartz-rocks of Merionethshire has fallen to 490 ounces in the period between October 1st, 1867, and December 31st, 1868.

There has been a small rush to certain gold-fields in Sutherlandshire. On a district not far from Helmsdale, which was known only to a few sportsmen and shepherds, recognized as the Kildonan Burn, a regular system of "Diggings" has been organized, and the burn has been christened as "Gold Creek." The results are not, however, satisfactory, since it appears that the most industrious gold-seeker cannot realize more than 5*s*. a-day.

METALLURGY.

Considerable differences of opinion still prevail as to the value of the Heaton steel-making process noticed in our last number. We have carefully read and considered all that has been said in favour of the process and against it. We are not by any means satisfied with the tone which has been assumed by those who have entered on the discussion of the question. Indeed, it is to be regretted that many of the statements which have been copied from paper to paper should ever have been made at all. They are obviously not consistent with our knowledge of the chemical changes effected in a

mass of iron when subjected to the action of nitrate of soda. We have been informed by one of the largest of the Sheffield steel manufacturers that, while he waits to see the result of a continuance of the experiments carried on at Langley Mills before he adopts it, he is strongly predisposed in favour of the process—that he regards it hopefully, and—we are bound to say it—that he is greatly pleased with the liberality and openness observed by Mr. Heaton. With these remarks—which we introduce mainly to convince our readers that we are not inattentive to the experiments in question—we leave the Heaton steel process until its more complete development removes it from the doubtful position in which it has been placed by injudicious advocacy.

A discussion of some interest in connection with the Heaton process has been opened in the pages of 'The Chemical News.' It arises out of a paper read before the Chemical Society, by Dr. B. H. Paul, on "The Connection between the Mechanical Properties of Malleable Iron and Steel, and the Amount of Phosphorus they Contain." Mr. W. Mattieu Williams, of the "John Brown and Co., Limited" Works, Sheffield, argues that Dr. Paul has shown an imperfect knowledge of his subject. That although Dr. Paul's conclusion that 0·50 per cent. does not impair the quality of steel is correct when it applies "*to tenacity as measured by a direct and gradually applied longitudinal or axial strain*," yet, that it is absolutely wrong when it is made to refer to steel which is to be employed for cutting instruments of any kind. "It is obvious that the power of resisting a sudden, a vibratory, and a transverse shock is the property most demanded," and that here the smallest quantity of phosphorus is highly injurious—"this is just the property which phosphorus tends to destroy."

Chromium steel has been attracting some attention. An alloy of chrome and iron can be made of sufficient hardness to scratch glass. Experiments are stated to be in progress, on a large scale, as to the practicability of making a chromium steel for rails, by adding chrome iron-ore and manganese to the iron in the puddling furnace.

At Pittsburgh (United States) some apparently successful experiments have been made in substituting a purely chemical process for the operation of puddling. Into melted pig-iron crushed hematite iron-ore is thrown—the oxygen of the ore combines with the carbon of the iron, removing it. The metal thus obtained is said to yield a very good iron, upon re-heating and squeezing in the usual manner. We believe a process much like this has been tried in this country and abandoned.

Works on Mining.—'*Under-ground Life; or, Mines and Miners*,' by L. Simonin, has been translated by Mr. H. W.

Bristow, F.R.S., and published in a very handsome volume by Messrs. Chapman and Hall. This is a book which could scarcely have been produced by an Englishman—the whole idea is essentially French—and it requires a Frenchman, with all a Frenchman's quick perceptions, and his love of exaggeration, to give form to the idea. Victor Hugo writes a clever romance—'The Toilers of the Sea;' and M. Simonin seizes on the idea, and writes a narrative of 'The Toilers of the Mine.'

"What he (Hugo) so happily calls the *ἀναγκη*, or irrepressible power of the Elements, addresses itself alike to the mariner and the miner, for each is the soldier of the deep, against whom the powers of nature wage at times their utmost fury." This paragraph gives the key to the whole book; and every action of the miner's life is seen through the medium which has been coloured by the influences of Victor Hugo's romance. The author professes to describe the struggle of the miner "in its reality, without exaggeration of any sort." This profession is not fulfilled, since every page of the original book is coloured beyond the truth; and with all the efforts made by the translator to subdue this sensational writing to a more sober tone, he has only partially succeeded in doing so.

'Under-ground Life' is, especially in its English form, nevertheless, a book full of interest; its interest depending upon the most graphic descriptions of the perils which attend all subterranean labours. Every detail of mining is fully and in most cases faithfully given; the tools, the lamps, the processes—from boring the ground in the search for coal, to the removal of the coal from its bed—are carefully described. The dangers which await the miner are drawn, as we have said, with a bold pencil; and, as in the drawings, so in the text, the explosion of fire-damp and of gunpowder, the inundation of a mine, or the collision of tubs in a shaft, becomes equally the subject of sensational drawing and writing.

After all, we are not certain whether in a book of this sort—a book intended for the public, and decorated to the extent which fits it for the drawing-room—the proper course has not been adopted, especially when the work was originally intended for the author's countrymen; and is now—with the interpolations on British Mining by the translator—produced as a popular Treatise on Mining.

M. Simonin naturally looks at mining from a French point of view; and, although he admits that mining in Great Britain is far more extensive than it is on the continent, he insists upon it, that the same amount of careful system is not observed in the English mines as is to be seen in the mines of France and Germany. Mr. Bristow, who has translated the book in a most creditable manner, and who has used considerable judgment in adapting it to the English reader, might have modified still further much that Simonin

had written. The difficulty of doing this we fully admit, and its danger. Many of the chapters must have been entirely re-written; and then, indeed, the work would have been no longer a translation of Simonin's, but the production of the English geologist, founded on the idea of the French mining engineer.

No one desiring an account of all the mining countries of the world, and of the methods by which the exploration of mines are carried out, can find in any one volume so much instruction on these points as in this one. Commencing with coal-mining, M. Simonin proceeds to the consideration of metalliferous mining; and follows this by descriptions of the processes of washing for gold, the search for gems, &c.; each division of the subject being treated with considerable detail—as to methods of working, statistics of production, and the like. For the latter, the author is under considerable obligations to 'The Mineral Statistics of the United Kingdom.'

The whole is most amply illustrated, and the chromo-lithographic plates of the minerals are beautifully executed. We have never seen anything of the kind to equal them. The new maps of the mining fields of all countries, which have been executed especially for this work by Mr. James Jordan, are of peculiar excellence, and give a very high character to this essentially popular book on mining.

'*Industrie Minérale de la Province d'Hainault*,' a report by Mr. F. Jocham, the Director of Mines in that province, gives a very full account of the process of coal-mining. From this report we learn that the production of coal in Belgium has been falling off, as will be seen by reference to our Chronicles of Mining.

The returns for 1868 have not yet been completed. The falling off is attributed to the depressed state of trade and manufacture; and the Belgian coal-owners look hopefully to the future. Another book of considerable value is '*Etude sur la Houille du bassin de Liége*,' by Leon Jacques. In this work a very detailed description of the collieries of this division of the Belgian coal-fields is given.

'*On the Haulage of Coal*,'—being the report of the Committee appointed by the North of England Institute of Mining Engineers to investigate this subject,—which has just been published at Newcastle-on-Tyne. This is a work of pure experimental detail, of the utmost value to all who are concerned in raising coal.

11. PHYSICS.

Light.—M. Janssen has forwarded a letter from Simla (Himalaya) to the French Academy of Sciences, in which, after giving further particulars respecting his discovery of the visibility of the spectra of

the protuberances on the sun's disk in full sunshine, he describes an ingenious plan by which he expects to be able to see the actual prominences at any time. The principle consists in getting one of the luminous lines into the spectral field, and then rapidly rotating the spectroscope. As the length of the luminous line depends upon the height of that part of the protuberance which it represents, it is evident that the rotation will cause the line to vary with the different widths of the elevations; and if the rotation is sufficiently rapid, the permanence of the impression on the retina will produce an accurate representation of the protuberance under examination.

Whilst M. Janssen only suggests an ingenious method by which these prominences *may* be seen, Mr. Huggins has actually succeeded in seeing them, as our readers will have seen from our 'Chronicle of Astronomy.'

A very beautiful experiment in spectroscopy has been described by Dr. Wallner. He passes the rapid discharges of a Leyden jar through an ordinary Geissler tube, and examines the light by means of a spectroscope. If the length of the discharge is increased a little, the sodium line immediately appears; and with a proper length of spark the brilliancy of the sodium line far exceeds that of the spectrum of the gas. By further increasing the distance of the discharge, the calcium line is produced with such intensity that it cannot be seen to greater advantage by any other method known. Finally, if the length of the spark is again augmented, the phenomenon changes, the light in the tube assumes a dazzling splendour, this luminous line forms a continuous brilliant spectrum in which the spectroscope reveals a completely black line instead of the sodium line; this, therefore, is the artificial production of a Fraunhofer line.

Microscopists will read with interest a very simple method of preserving animal specimens for fine dissection. It is described by Dr. Alcock. The advantages of the plan are—very perfect preservation; no necessity for closing up, so that the specimen cannot be got at; no fear of losing a valuable dissection from accidental evaporation, as where spirit is used; lastly, cheapness. The method adopted is to prepare a saturated solution of corrosive sublimate in alcohol, and when a dissection in water is in progress, a small quantity, as half-a-teaspoonful, of the solution is to be added from day to day if the slightest appearance of putrefaction is observed, but no more of it is used than is absolutely necessary; and by the time the dissection is completed, the specimen has become imperishable from the union of the corrosive sublimate with the tissues, and it may then be kept in pure water, either open or mounted in the usual way.

The oxyhydrogen light, in which the burning jet of mixed gases is allowed to impinge on a piece of Zirconia instead of Lime, is gradually being introduced in Paris. The advantages of employing Zirconia are, that of all the known earthy oxides it is the only one which remains entirely unaltered when submitted to the action of the blowpipe fed by oxygen and hydrogen. Zirconia is also, of all the earthy oxide , the one which, when introduced into an oxyhydrogen flame, develops the most intense and the most fixed light.

All persons interested in optical researches will be glad to hear that Messrs. Chance are now making optical glass of a density of 4·4. Glass of this density has never before been prepared commercially in England, although we believe it has long been made and used in France.

Heat.—M. Le Roux has made some experiments with the vapour of sodium, and examined its capability or incapability of passing through rock-salt. Two crucibles of rock-salt were prepared, a thin plate of the same substance placed between them, and in one of the cavities sodium was placed.

Notwithstanding a bright red heat maintained for several hours, the piece which was not in direct contact with the sodium vapour remained completely unaltered, even where it had been in contact with the plate already completely penetrated. Chloride of sodium is not attacked by the vapour of sodium, but soda corrodes it energetically. A very small quantity of soda suffices to hermetically seal two surfaces of rock-salt, sodium preserving its lustre for several months in a crucible of this kind. Potassium vapour does not attack its chloride, but it covers the chloride with a bright blue substance, in which, possibly, chemists recognize the suboxide of potassium.

Mr. W. P. Dexter has described a new gas-lamp for heating crucibles, &c. The ordinary Bunsen burner is known to act upon the surface of platinum vessels brought into contact with the inner line of the flame; the metal loses its polish, becoming superficially porous and spongy, and requires the use of the burnisher to bring it back to its original state. This alteration of the surface is attended with a change of weight, and Mr. Dexter has consequently devised the following arrangement:—He removes the air-tube of a common Bunsen lamp, and puts in its place a somewhat longer one of glass or iron, of about 12 millimètres internal diameter. The gas-jet has a single circular aperture, and should be in proper proportion to the diameter of the tube, which may be held in any of the ordinary clamped supports. The tube being raised sufficiently above the jet to allow free entrance of air, and a full stream of gas let on, a "roaring" flame is produced, of which the

interior blue cone is pointed, sharply defined, and extends only about half-an-inch from the top of the tube. A polished platinum surface is not acted upon by this flame, provided it be not brought into contact with the interior cone.

In the Bunsen burner, as usually made, the supply of air depends upon the diameter of the tube, the holes at its base being more than sufficient to supply the draught. With the wider tube, it is necessary to limit the admission of air by depressing the tube upon the lamp, when the force of the gas is diminished. Otherwise the proportion becomes such that an explosive mixture is formed. For this reason it is more convenient to use an arrangement in which the excess of air can be regulated by an exterior tube sliding obliquely downward over the air-apertures. The gas-jet should be on a level with the top of these apertures, which must be much larger than those of the ordinary Bunsen's burner.

Mr. Brown, of the War Office Chemical Department, has discovered a remarkable property connected with the ignition and explosion of gun-cotton. He has found that the explosive force of gun-cotton may, like that of nitro-glycerine, be developed by the exposure of the substance to the sudden concussion produced by a detonation; and that if exploded by that agency, the suddenness and consequent violence of its action greatly exceed that of its explosion by means of a highly heated body or flame. It follows, that gun-cotton, even when freely exposed to air, may be made to explode with destructive violence, apparently not inferior to that of nitro-glycerine, simply by employing for its explosion a fuse to which is attached a small detonating charge. Some remarkable results have been already obtained with this new mode of exploding gun-cotton. Large blocks of granite and other very hard rock, and iron plates of some thickness, have been shattered by exploding small charges of gun-cotton which simply rested upon their upper surfaces. Further, long charges or trains of gun-cotton, simply placed upon the ground against stockades of great strength, and wholly unconfined, have been exploded by means of detonating fuses placed in the centre or at one end of the train, and produced uniformly destructive effects throughout their entire length, the results corresponding to those produced by eight or ten times the amount of gunpowder when applied under the most favourable conditions. Mining and quarrying operations, with gun-cotton applied in the new manner, have furnished results quite equal to those obtained with nitro-glycerine, and have proved conclusively that if gun-cotton is exploded by detonation, it is unnecessary to confine the charge in the blast-hole by the process of hard-tamping, as the explosion of the entire charge takes place too suddenly for its effects to be appreciably diminished by the line of escape presented by the blast-hole. Thus the most dangerous of all operations connected

with mining may be dispensed with when gun-cotton fired by the new system is employed.

Electricity.—M. Becquerel, in his sixth memoir 'On Electro-Capillary Actions,' describes the processes which he employed to obtain a great number of hydrated oxides in the crystalline state. In a vessel containing a solution of nitrate of copper, a smaller vessel, one side of which was composed of parchment paper, was placed, containing aluminate of potash. Nitrate of potash was produced, but in the place of aluminate of copper in the porous vessel, crystals of hydrated alumina presented themselves; and on the outside, crystals of hydrated oxide of copper formed. By replacing the aluminate of potash by silicates, M. Becquerel obtained hydrated silica sufficiently hard to scratch glass.

A new arrangement for furnishing currents of electricity has been made known by M. Ney. It is composed as follows:—(1) a vessel filled with solution of chloride of ammonium, containing a plate of amalgamated zinc; (2) a porous cylinder filled with carbonate of copper, into which a plate of copper plunges. To maintain the battery in action, it is only necessary to add solid chloride of ammonium from time to time. In military telegraphy, where the pile should be capable of transport, the outer vessel might be filled with sand saturated with a solution of chloride of ammonium in the place of the solution. This arrangement recommends itself on the score of cheapness, for native carbonate of copper answers sufficiently well, and it likewise only requires attention while in actual use. Carbonate of copper is insoluble in a solution of chloride of ammonium, but upon closing the current, the chloride is decomposed into hydrochloric acid and ammonia; the hydrochloric acid collects at the zinc pole, the ammonia at the copper. The carbonate of copper becomes soluble, and its reduction gives rise to a secondary current having the power of a Daniell's element. This form of battery is perfectly constant.

Mr. Gore has recorded some experiments on the electrolysis of hydrofluoric acid, both anhydrous and hydrated. They are interesting as showing the extreme energy and refractory character of that almost unknown element fluorine. With the anhydrous acid he has used anodes of gas-carbon, carbon of lignum-vitæ, and of many other kinds of wood, of palladium, platinum, and gold. The gas-carbon disintegrated rapidly; all kinds of charcoal flew to pieces quickly, and the anodes of palladium, platinum, and gold were corroded without evolution of gas. The acid with a platinum anode conducted electricity much more readily than pure water; but with one of gold it scarcely conducted at all. These electrolytic experiments presented extreme difficulties, and were conducted

in a platinum apparatus specially devised for the purpose. Scarcely more satisfactory results were met with in the experiments of electrolysis of the aqueous acid of various degrees of strength, made with anodes of platinum. Ozone was evolved; and with the stronger acid only, the anode was corroded at the same time.

M. Berthelot has examined the action of the electric spark on marsh gas. When a succession of powerful sparks is made to traverse pure marsh gas, carbon is deposited, and the volume of gas augments considerably. Operating with 100 c. c., this volume becomes 127 c. c. at the end of two minutes, 154 c. c. at the end of ten minutes, and so on; but some hours are required for the complete destruction of the marsh gas. That no marsh gas remains at the end of the experiment may be demonstrated after removing the acetylene and the traces of condensed vapours which are present mixed with hydrogen.

12. ZOOLOGY—ANIMAL MORPHOLOGY AND PHYSIOLOGY.

Singing Mouse.—A gentleman relates in one of our contemporaries the discovery of a "singing mouse" in his kitchen, which he and his daughters listened to with much delight, the notes being like those of a canary, but very much subdued. He suggests that the mouse may have taken to imitating a canary kept in the house, which he states is the case with field-mice. We need hardly say that this is a somewhat startling explanation; a more likely one is that the singing is the result of spasmodic breathing caused by the presence of a parasite—the *Cysticercus fasciolaris*—in the liver of the poor little songster, since in every case of a singing mouse examined these parasites have been found. But apart from this source of irritation, it is curious that mice should possess the power of singing like a bird. The Rodents are so exceedingly bird-like in many of their habits and structural characters, that one is almost prepared to find some of them able to sing. It is a common mistake to suppose that as a rule birds sing; the vast majority do not. It seems impossible to account for the existence of the faculty in a few birds. Why do they sing? How are they benefited by it in the struggle for existence?

A Sword-fish scuttling a Ship.—A case lately came on before one of the London courts in which the question was raised as to whether a vessel had been struck by a sword-fish, which afterwards had withdrawn its sword, and thus caused a leak which injured the ship's cargo. Professor Owen (who is now travelling Egypt

in order to avoid the winter weather) gave evidence as to two cases which had come under his observation, in which sword-fishes had struck vessels; but in both cases the sword had been broken off in the animal's subsequent struggles, thus filling up the hole. The fish's snout in the first case penetrated into fourteen inches of wood; in the second case it had passed right through the timbers and into a berth. In the case under discussion it appeared that only three inches of wood had been penetrated; and Professor Owen thought that a sword-fish might get its nose out of that depth again. The force exhibited in the penetrating power of these blows from the sword-fish is something enormous. The *Xiphias* is a true fish, its sword being formed of two facial bones —the vomer and præmaxillary. It must not be confused with the saw-fish, nor with the cetacean narwhal, whose sword is one of a pair of teeth, which grows to the enormous length of ten feet in some of the males, whilst the other remains small, as do both in the females. The sword-fish and the narwhal are about the same size—a little over twelve feet in length.

The Auditory Organ of Molluscs.—Professor Lacaze-Duthiers has made a very important communication to the French Academy on this subject. Leydig, Huxley and Claparède, and M. Duthiers himself, too, had thought that the otolithic sac of Molluscs, with the exception of Eolidæ and Heteropoda, derived its nerve from the pedal ganglion, since it lies quite on that ganglion; but M. Duthiers has now found that this is a mistake, and that the nerve really comes down to the otolithic saccule from the supra-œsophageal ganglion or brain-ganglion, as in Heteropoda, so that all the organs of sense are presided over by this cerebral ganglion.

The Annelids of the Bay of Naples.—Professor Claparède, of Geneva, having had to pass a winter at Naples for the sake of his health, has produced one of the most beautiful volumes that we have ever seen, on the annelids of its bay. The volume is a quarto one, with thirty-two plates containing innumerable drawings of microscopic structure and detail, and charming coloured figures of the annelids themselves. There is no exaggeration of colour, and the lines are the work of a true artist. Nothing could be more beautiful than the figure of *Phyllochetopterus*. The work is a most important one, moreover, for many new species are described, and—what is of more importance—much that is new in the structure of known forms is told and figured.

A New Type of Polyzoa.—Professor Allman, of Edinburgh, obtained from Mr. Gwyn Jeffreys a most interesting and quite new form of Polyzoa, which was dredged up off the Shetlands. In the 'Quarterly Journal of Microscopical Science' the Professor has described and figured the new molluscoid under the name of *Rhabdopleura*. It is so called from the presence of a remarkable chitinous rod

which occupies the centre of the branching tube, in the free ends of which the polypides live. This rod spreads out below the particular cavity occupied by an individual, and there gives attachment to the "funiculus" which attaches the polyzoon to its tube. Another remarkable thing is that the polypides are hippocrepian; but still more important and new is the presence of a convex body on each side of the lophophore, which Professor Allman compares to the mantle of the Lamellibranchs; and he proceeds to show, by two most instructive diagrams, that the resemblance between the Polyzoa and the Lamellibranchs is closer than between them and the Brachiopods, to which they have so frequently of late years been assimilated.

The simplest Living Forms.—In the 'Quarterly Journal of Microscopical Science' for October, Professor Huxley described the viscid substance which abounds everywhere in the mud of the Atlantic bottom, giving to it its sticky character, and containing the small ovoid bodies known as coccoliths—and gave to this substance the name of *Bathybius*, regarding it as an organism probably living by absorption of mineral matter, but not to be certainly referred either to plants or animals. In the same Journal a most interesting paper, by Ernst Haeckel, of Jena, the renowned author of the 'Radiolarien,' and of the 'Morphology of the Organism,' is being published, in which the very lowest forms of animal life—or of life at all—are described—*Protogenes*, *Protomyxa*, *Protomæba*, and others, forming the group Monera—minute bits of living jelly, devoid of all structure, of nucleus, or vacuole, but capable of most active movement, embracing solid food, and digesting it; and at times becoming encysted, and breaking up into spores or gemmules, which grow in time into adult Monera.

Deep-sea Dredgings.—Naturalists have suddenly been aroused to the importance of investigating the fauna of the deepest sea-bottoms with the dredge. Soundings no longer are to be considered satisfactory, but "the dredge, with its iron edge, and mystical triangle" is to explore the ocean-floor at depths of a mile or two. The results obtained by Lovén and Sars incited Professor Wyville Thomson and Dr. Carpenter to a like exploration—their results are most important in what relates to the temperature of the deeper currents. Dr. E. P. Wright's little excursion off Portugal, where he dredged in 600 fathoms, produced some interesting facts, besides the confirmation of Bolage's discovery of *Hyalonema;* especially as to the presence of a shark and of *Chiasmodon* at these depths. On what do these fishes feed? The American dredgings, however, promise to be the most interesting, and the most fully carried out. The Superintendent of the Coast Survey (why have we not one likewise in England?) no sooner perceives the importance of these dredgings than he arranges for deep-sea dredgings in the region of

the Gulf Stream—actually within the Gulf of Mexico. Mr. L. F. de Pourtales has had the direction of this matter, and gives a most promising account of dredgings at a depth of 400 to 500 fathoms, and also at 300 fathoms. In this last region he found the most common mollusc to be *Terebratula Cubensis*—a new species; and also a *Waldheimia*, both of large size. This Terebratula is of great interest; for before this, only two living species of that genus—so abundant in Oolitic and Cretaceous times—were known: the one, *T. vitrea*, found in the Mediterranean; the other, *T. uva*, a unique specimen from the coast of Mexico. This tends to confirm the idea of Sars—that in these deeper parts of the sea-bottom many forms thought to be extinct may be still lingering on—or at any rate be represented—not able to encroach on the fauna which occupies the shallower water, but kept down by the advancing coast-fauna to the lower regions, like prisoners in a dungeon. The case is comparable to that of "Alpine" floras, which are now kept to the top of high hills and mountain slopes, but which must once have spread from these spots to Arctic regions. Mr. de Pourtales found Gasteropods rare at a depth of 300 fathoms, Acephala rare and small, but Bryozoa abundant. The most common Echinoderm was a new species of *Cidaris*, besides which there were other forms, and a new *Psolus*. Eighteen new species of corals, and other new Cœlenterates are mentioned. No sea-weeds were obtained. Some animal remains were found whose presence is accidental, such as sharks' teeth, bills of Cephalopods, shells of Pteropods, and fragments of bones of the Manatee. A new Crinoid (probably the same as the *Rhizocrinus* of Sars), considered to belong to the genus *Bourgueticrinus* of D'Orbigny, was obtained—possibly identical with a species found fossil in Guadaloupe. In the presumed absence of vegetable life, we may fairly ask, What do these animals feed on? They cannot eat one another, or there would soon be an end to them. Must we suppose that the *Bathybius* of Professor Huxley is here organizing food from mineral matter?

The Fauna of the Victoria Docks.—Mr. Kent, of the British Museum, at one of the excursions of the Quekett Club to the Victoria Docks, discovered a new Nudibranch, of the genus *Embletonia*, which he calls *E. Grayii*, also a new Polyzoon, large numbers of a species of Mysis, the respiratory organs of which he has been investigating, and besides these, that most interesting fresh-water Hydrozoon, *Cordylophora*. These interesting forms are associated with a vast variety of fresh-water Rotiferæ, Entomostraca, and Infusoria. The occurrence of *Embletonia* in this position is exceedingly interesting. It appears from some observations of Dr. Gray, that *Embletonia pallida* is found in the Baltic, extending far up into that part of the sea where the water becomes almost fresh. Hence the occurrence of the genus in the brackish

or nearly fresh-water of Victoria Docks is not without parallel. It is an important subject for inquiry, as to how the fauna of the Victoria Docks originated. Is it the representative of an ancient marsh fauna, presenting in its Nudibranch and Hydrozoon an indication of the recession of the sea? Or has Embletonia been introduced with ships and established itself, and has *Cordylophora*, long since adapted to lacustrine conditions, also been introduced since the time when the area was a marine one?

Physiology.

Influence of Section of the Pneumogastric Nerves on Respiration.—Herr Voit, of Munich (a physiologist, whose writings on the subject of the connection between muscle-oxidation, food, and muscular work, as opposed to Liebig's old teaching, were of much value, and of early date in the late revulsion of scientific opinion on that subject), has experimented on the effect of cutting the pneumogastrics as to respiration. Previous experimenters have shown that the amount of carbonic acid exhaled after section of the nerve, is the same as that before. The author and Dr. Raber find now that this is true only for the first few hours after the operation. At a later period when the tissue of the lung has begun to undergo a change, the quantity of carbonic acid diminishes rapidly, and that of oxygen is increased.

Influence of Respiration on the Temperature of the Blood.—Dr. Lambard, of whose wonderfully delicate thermo-electric apparatus we spoke in our last Chronicle in relation to the temperature of the head, capable as it is of indicating a difference of temperature of about $\frac{1}{2000}$th of a degree centigrade, has been applying his instrument to the study of the effects of respiration on the temperature of the blood. One apparently anomalous result which he obtained is this—though the air taken into the lungs, and consequently into the blood, be quite cold and dry, it does not lower the temperature of the blood sufficiently to be appreciable by this delicate thermometer, as compared with the temperature when the air respired is hot. We must all of us have noted the feeling of heat in the lungs on a cold frosty day—a sensation which is not experienced in warmer weather, and which is the very reverse of what we should expect from the greater coldness of the inspired air. M. Brown-Séquard suggests that the explanation may be this—the lower the temperature of the inhaled oxygen the greater will be the amount absorbed according to a well-known law in physics, and hence possibly, there being a larger absorption of oxygen, there may be increased oxidation, and increased heat accordingly. The tension of the vessels affected by cold air, may have some connection with the sensation in the lungs.

Poison of Snakes.—M. Vulpian, of Paris, a well-known physiologist, received some dry and some moist poison of the Cobra di capello, which had been forwarded from India by Mr. Shortt. He proceeded to try its effects upon frogs, rats, and rabbits, and had especially in view the object of testing the truth of Dr. Halford's observations as to the extraordinary increase of white corpuscles in the blood of bitten animals. In the condition in which he was able to study it—a condition in which its activity is without doubt notably diminished—M. Vulpian found that the poison appeared to act on the central nervous system, the functions of which it little by little suppressed, producing a state of somnolence of a remarkable kind. In frogs it produces an effect similar to that induced by curare; it abolishes the action of motor nerves on the muscles as regards contractility. The movements of the true heart persist some time after death, whilst those of the lymphatic hearts cease very soon, as in frogs poisoned by curare. It is hardly necessary to say that the results of the action of the poison of the Cobra di capello, relatively to the muscles and to the nerves, has nothing peculiar about it; for we know now more than twenty toxic substances which destroy the function of the motor nerves as regards muscular contractility. As to the blood, M. Vulpian has *not* confirmed the existence of the modification described by Halford, and has seen nothing at all like it. He finds (and this is a peculiarly interesting fact) that the buccal mucous membrane is capable of absorbing the poison, and that the same symptoms are produced as when the poison is absorbed from a wound. Those who have had the opportunity have lately been busy in examining snake-poison.

A writer in the 'Lancet' details some experiments, in which he failed to produce the effect on the blood described by Halford and by Jones. It appears to us quite possible that the intensity of the poison might affect this condition very much, and that while being sufficiently powerful to kill, M. Vulpian's specimens of poison may have failed to produce the exaggerated leucœmic condition simply from the loss of intensity or of a special quality acting on the blood itself or on the hœmopoietic glands. Some remarkable cases of cure from snake-bite are reported in the medical journals, as effected by Dr. Halford in Australia, by the injection of ammonia subcutaneously and into the veins. Ammonia has long been used as a stimulant in these cases, and the injection seems to be merely a more direct method of application, the object being to counteract the drowsiness which comes on. Colonel Showers records some striking instances of cure from snake-bite effected by a native Hindoo with certain herbs. If M. Vulpian is right in regarding the mode of action of snake-poison as similar to that of curare, it seems not improbable that vegetable principles should exist having

an opposite physiological effect, and therefore capable of neutralizing it.

An Experiment with a Scorpion.—Mr. Frank Buckland gives an amusing account in his 'Land and Water' of a fight between a mouse and a scorpion. He received two scorpions from Egypt through Mr. J. Keast Lord, who is now exploring the Red Sea for the Viceroy, and turned one of them into a bell jar with a freshly-caught mouse. The scorpion was not one of the big African species, but a little fellow, the body being about the size of a large cockroach, and the tail of course additional. He carried this last over his head, and when brought up to the mouse let out with it in furious style, stabbing the mouse several times, who did not seem to mind it much, except one blow received on the nose which he wiped with his fore paw. The mouse proceeded to bite off two of the scorpion's legs and also injured his tail so that he could not sting. Mr. Buckland expected after a while to see the scorpion's poison take effect, but nothing of the sort ensued, and the last scene in the drama was the mouse quietly devouring the body of its late antagonist. The journey from Egypt in a box without food, and in cold weather, doubtless had affected the scorpion's secreting powers; he was suffering from an exhausted nervous system.

Quarterly List of Publications received for Review.

1. The Malay Archipelago. The Land of the Orang-Utan and the Bird of Paradise. By Alfred Russel Wallace. 2 vols. *Illustrated with Plates and Woodcuts.* *Macmillan & Co.*
2. The Polar World. A Popular Description of Man and Nature in the Arctic and Antarctic Regions of the Globe. By Dr. G. Hartwig. *With* 8 *Chromolithographs and Woodcuts.* *Longmans & Co.*
3. The Theory of Ocular Defects and of Spectacles. Translated from the German of Dr. Hermann Scheffler. By Robert B. Carter, F.R.C.S. *Longmans & Co.*
4. On Molecular and Microscopical Science. By Mary Somerville. 2 vols. *With Illustrations.* *John Murray.*
5. Circle of Light, or Dhawalegeri. By H. P. Malet. *J. C. Newby.*
6. Sciography; or, Radical Projection of Shadows. By R. Campbell Puckett, Ph.D. *Chapman & Hall.*
7. Underground Life; or, Mines and Miners. By L. Simonin. Translated and Edited by H. W. Bristow, F.R.S. *Illustrated with* 160 *Wood Engravings,* 20 *Maps, and* 10 *Chromolithographs.* *Chapman & Hall.*
8. Lectures on the Preservation of Health. By Chas. A. Cameron, Ph.D., M.D. *Woodcuts.* *Cassell, Petter, & Galpin.*
9. Physical and Historical Evidences of vast Sinkings of Land on the North and West Coasts of France and South-Western Coasts of England, within the Historical Period. R. A. Peacock, C.E. *E. & F. N. Spon.*
10. Handbook of Natural Philosophy. By D. Lardner, D.C.L. Optics. Sixth Thousand. Edited by T. O. Harding, B.A. *James Walton.*
11. Preglacial Man, and Geological Chronology. By J. Scott Moore. *Dublin: Hodges, Smith, & Foster. London: Williams & Norgate.*
12. Facts and Arguments for Darwin by Fritz Müller. Translated from the German by W. S. Dallas, F.L.S. *John Murray.*
13. Medicine in Modern Times. By Dr. Stokes, Dr. Acland, Professor Rolleston, Rev. Prof. Haughton, and Dr. Gull. *Macmillan & Co.*

PAMPHLETS AND PERIODICALS.

Observations on the Spectra of some of the Stars and Nebulæ, &c.; also Observations on the Spectra of the Sun and of Comet II., 1868. By William Huggins, F.R.S.

On the Home Produce, Imports, and Consumption of Wheat. By J. B. Lawes, F.R.S., and J. H. Gilbert, F.R.S. *Longmans.*

Vital Law. *Longmans.*

On the Coal Measures of the Neighbourhood of Rotherham. By A. H. Green, M.A., Geol. Survey.

On the Prevention of excessive Infant Mortality. By Mrs. Paines.

On the Condition of the Metallic Currency of the United Kingdom, with reference to the Question of International Coinage. By W. Stanley Jevons, M.A. *Harrison & Sons.*

Notes on the Extinct Floras of North America, &c. By J. S. Newberry, Columbia College, New York.

On the Origin of Genera. By E. D. Cope, A.M. *Philadelphia: Merrihew & Son.*

More Light. *Wyman & Sons.*

On the Influence of Mind on the Molecular Forces of Matter. By Dr. J. B. Nevins.

Invention of the Electric Telegraph. *Simpkin, Marshall, & Co.*

Revue Bibliographique Universelle. *Paris: Aux Bureaux de la Revue.*

Polytechnisches Notizblatt für Gewerbtreibende, Fabrikanten und Künstler. Herausgegeben und redigirt v. Prof. Dr. R. Bœttger in Frankfurt. a. M. *C. G. Kunze's Nachfolger.*

Nachrichten von der Königl. Gesellshaft der Wissenschaften und der G. A. Universität zu Göttingen.

Revue Hebdomadaire de Chimie Scientifique et Industrielle, sous la Direction de M. Ch. Mène. *Paris: Ch. Mène.*

Catalogue of American and Foreign Scientific Books for Sale by *D. van Nostrand, New York.*

Van Nostrand's Eclectic Engineering Magazine. *Same Publisher.*

The American Naturalist.

The Geological Magazine. *Trübner & Co.*

The Canadian Naturalist and Geologist.

The Quarterly Journal of Microscopical Science. *J. Churchill & Sons.*

The Westminster.

Scientific Opinion.

The Popular Science Review. *Hardwicke.*

The Public Health.

Notes on Books. Being an Analysis of the Works published during each Quarter by *Longmans.*

PROCEEDINGS OF LEARNED SOCIETIES, &c.

Thirty-sixth Annual Report of the Royal Cornwall Polytechnic Society.

Transactions of the Edinburgh Geological Society.

Proceedings of the Essex Institute, Salem, Mass.

Proceedings of the Royal Society.

" " Royal Astronomical Society.

" " Royal Geographical Society.

" " Geological Society.

" " Zoological Society.

In the present Number (XXII). of this Journal will be found, besides numerous Short Notices of Books, Pamphlets, and essays, Reviews of the following recent works on Scientific subjects:—

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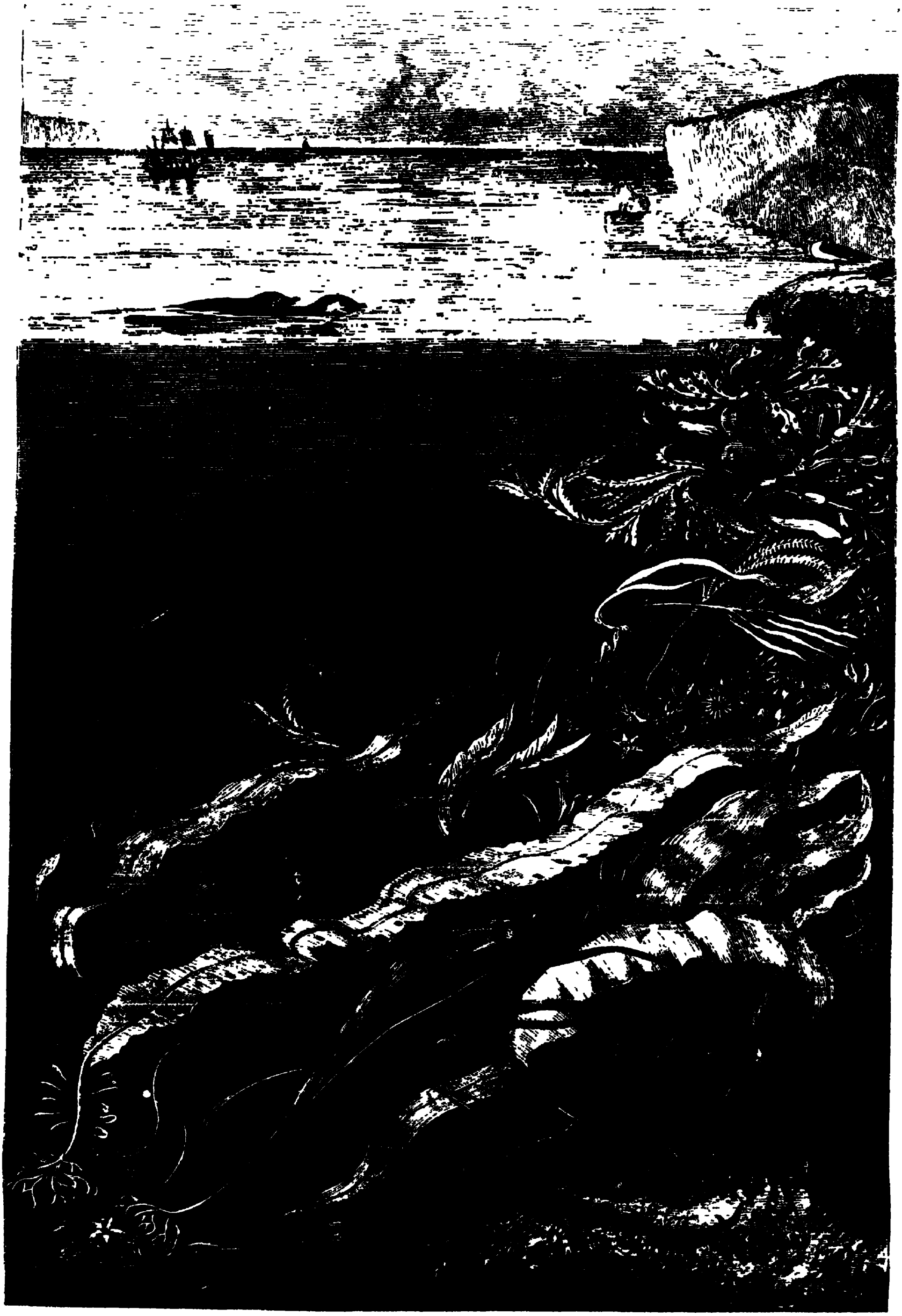


IDEAL SKETCH OF SUBMARINE GARDEN ON THE COAST OF YAR-CONNAUGHT.

The characteristic Sea-Weeds are:—*Fucus nodosus*, *F. vesiculosus*, *F. serratus*, *Laminaria digitata* (*vera*), *L. digitata*, var. *stenophylla*, *L. saccharina*, and *Alaria esculenta*.

THE QUARTERLY

JOURNAL OF SCIENCE.

JULY, 1869.

I. THE SEA-WEEDS OF YAR-CONNAUGHT, AND THEIR USES.

By G. H. Kinahan, M.R.I.A., F.R.G.S.I., &c., &c., of the Geological Survey of Ireland.

On the west of Lough Corrib, the second largest sheet of fresh water in Ireland, forming the north-western part of the Co. Galway, lies the district called Yar or West Connaught. The western portion of this tract, included in the Barony of Ballinahinch, is called Connemara; however, now-a-days tourists seem to have given the latter title to the whole of Yar-Connaught, although the natives still retain the ancient names.

Yar-Connaught lies on the Atlantic Ocean, being on the west and south-west indented by numerous fiords, bays, and cooses, and along its sea-board the fuci vegetate luxuriantly.

The sea-weeds are used for manufacturing into kelp, also as manure for the land, and are locally divided into three classes, which have received as names—1st, *Red weeds*, or the iodine producing plants that grow below the low-water mark of neap tides; 2nd, *Reeshagh*, or the non-iodine producing weeds that grow in similar situations; and 3rd, the *Black weeds*, growing on the rocks between high and low water.*

The first, in the order of importance as sources of iodien, are "Laminaria digitata vera," "L. digitata stenophylla," "L. saccharina," "L. phyllitis," and "Alaria esculenta." The *Black weeds*

* To John Steven, Esq., of Mullaghmore, the representative of William Patterson, Esq., of Glasgow, I am indebted for the classification of the fuci, and also for many of the statistics in this paper.

proper, grow between high and low water; such as "Fucus vesiculosus," "F. nodosus," and "F. serratus," with many others of little importance; besides these are the weeds found in deep waters, that have somewhat the aspect of the Red weeds, and are called *Reeshagh*, namely, "Chorda filum," "Himanthalia lorea," and "Laminaria bulbosa." The last named are burned along with the black weed by fair dealers in kelp, but by others are used to adulterate the red weed, although they contain merely a trace of iodine; sometimes, however, they may be added to compensate for the soluble salts lost from the red weed that has long been exposed to the atmosphere, as the influence of the latter partially decomposes the weed, and the alkaline salts liberated are washed away, including much of the iodine compounds. If this damaged weed is burned alone, the earthy salts and matter in excess from the loss of the alkalies, cause the mass to be comparatively infusible, and very difficult to burn, but by adding "reeshagh" (which is rich in "Ile" (oil), as the natives say, but in reality on account of its containing much of the potash and soda salts) the infusibility of the earthy salts is corrected, and the product is a nice-looking, well-fused mass, yet necessarily poor in iodine. This is the plan usually adopted with damaged red weed; but good burners, instead of using "reeshagh," add to it fresh well-saved red weed, as the latter contains sufficient alkaline salts to flux the earthy salts and matter of the old weed, and form the mass into a kelp containing all the iodine salts of the new weed with whatever remains in the damaged article. Necessarily the product will not have as high a percentage of iodine as if the kelp was manufactured from the fresh well-saved red weed alone; however, the kelp procured from the mixture is found to pay better than if the iodine which remained in the damaged weed were totally lost, and without some flux or another it is unattainable.

Sea-weeds grow much more rapidly in strong tidal ways than elsewhere. In such localities the black weeds arrive at maturity in two years, while in the land-locked cooses, creeks, and bays, where there is a sluggish tide, they will take three or even four years. The growth of the red weeds is also affected by the tide, the plants being more luxuriant in a good race than elsewhere.

The great sea-weed harvests are in the spring and summer months; nevertheless, during the winter the inhabitants of the coasts collect what may be driven in by the tides and storms, which is locally known by the names of "Claddagh," or "Sea-wrack," to spread on the lands they intend to till and crop subsequently. In the spring of the year the great work begins, as the inhabitants then cut from the rocks the two or three year old plants, according to the situations in which they are

growing,* and much of this weed they send by boat for sale at Galway, or some of the small towns on the south or east of Galway Bay, from whence it is brought by carts, or even by the railways, into the interior of the country, to be used as a fertilizer for the land; while the "seawrack" that may be driven in during this period, they save by drying n the sun; some to be burned into kelp, while more, later in the year, will be sent away in boats to be sold as manure for the late potatoes and turnip crop.

The burning or kelp manufacture usually begins in the latter end of April, but sometimes earlier, if the spring has been dry and hot, and is carried on until the end of September; however during a fine dry autumn they may keep the fires lighted all October or even November, but this depends entirely on the weather and the quantity of weed they are able to save, as in Yar-Connaught, except in the Aran Islands, the drying process is altogether effected by atmospheric heat.

In former years there was an extensive trade in black weed kelp, as the prices ranged from £15 to £20 a-ton; most of the soda used in the manufacture of soap, glass, &c., being procured therefrom. But the duty having been taken off salt, cheaper methods were resorted to, such as that discovered by M. Lablanc, for obtaining soda from common salt, through its decomposition by sulphuric acid. The adaptation of M. Lablanc's celebrated process rendered black weed kelp almost valueless as a source of soda, and this trade, for soap-making purposes, ceased about the year 1840. Its loss not only affected the inhabitants of Yar-Connaught, but also the people living on the west coast of Scotland, particularly the inhabitants of the Hebrides, whose country, as well as their manner of living, resemble those of Yar-Connaught. From the Hebrides many of the inhabitants emigrated, while in Yar-Connaught the people became poorer and poorer till the famine of 1846 and the following years, during which visitation many of them found a resting-place in their graves.

After the great trade in the black weed succumbed, a new one sprang up in red weed kelp, for obtaining the marine salts, which yield iodine, bromine, &c.; but this trade was not of much importance until after the year 1845, since which it has become annually more and more developed. It should here be mentioned that to William Patterson, Esq., of Glasgow, Yar-Connaught is

* The inhabitants of this coast have an ingenious way of saving themselves the trouble of carrying the weed they cut on the rocks, by throwing it as cut in a heap, and, before the tide rises to it, tying it round with a hay or grass rope, locally called a *sūgaun*. This heap rises with the tide, and can be easily towed to whatever part of the shore they wish. This practice seems to have been in vogue for at least 200 years, as it is mentioned by Roderick O'Fflahertie in his history of 'Hiar, or West Connaught,' which was written in the year A.D. 1684.

principally indebted for this source of industry. He introduced and fostered it, and now carries on an enormous trade along the west and north shores of Ireland, from the mouth of the Shannon to Glenarm.

Of the red weed, that known to botanists as "Laminaria digitata vera" is the principal weed of Yar-Connaught, and of this plant Mr. Steven believes that he has remarked two distinct varieties. "One which sheds its frond early in April and May, and when dried and stacked for a time, does not yield any *mannite;* while the other, parts the frond and *a portion of the stem besides*, in July, and gives out quite as much *mannite* as the 'L. saccharina.' Of the other red weeds some varieties fall in June, July, August, or September, but all the 'Laminariæ' are supposed to shed the frond twice a year."

Doctor Harvey thus describes the separation of the old leaves from the stems:—"As soon as the existing frond has served its purpose and begins to grow brown, an expansion commences between its base and the apex of the stem. This expansion continues to increase in length and breadth till it has attained a considerable size. We have then a large ovate lobe at the apex of the stem, separated by a deep constriction from the old frond. As yet this lobe is quite entire; but after awhile longitudinal splits, commencing near its margin, and continuing towards its centre, begin to appear. These widen and lengthen by degrees, and at last the outer ones reach the decaying base of the old frond; a rupture ensues, and the tip of the new segment is free. This process is continued, until, when many segments have thus been formed, the connection between the old leaf and the now nearly perfect new one is so much weakened, that the former adheres by a very small surface, and is soon cast off altogether."*

The fronds of the red weeds are driven on the shore by the first gale after the plants begin to shed, whereupon hundreds of men, women, and children immediately congregate at the different cooses or small bays to collect the weed driven in, and carry it inland on their own or on ponies' backs. The produce of the spring and summer harvests is usually spread, dried, and stacked to be burned into kelp; while that driven in during the late autumn and winter (unless the weather is extremely fine) is spread on the land as manure for the spring crop. The weed thus treated for manure is supposed by the natives to retain its fertilizing properties, while any which may be left above high-tide mark until it ferments, they consider would be rendered useless. This, however, is controverted by scientific men, as they say "the best way of using sea-weed for

* 'Phycologia Britannica,' by W. H. Harvey, M.D., M.R.I.A., &c., &c., vol. i., syn. 24.

manure is to allow it to ferment above high-water mark in alternate layers with either turf-mould or clay, and that the native plan is very wasteful in every respect."

If the sea-weed is to be used for kelp burning, a gravelly beach (if there be no fine sand) is considered a good place on which to have it driven; but if there is sand the latter will adhere to the weed and cannot be got off even when it is dried, therefore both must be burned together. This deteriorates the kelp, as it adds considerably to its weight, and also decomposes the iodine compounds, which causes some of that metalloid to be volatilized—the former being a loss to the buyer and the latter to the seller.*

The weed having been fully dried, is stacked in heaps until a sufficient quantity is collected, when the fires are lighted. The burning is effected in rude kilns built of loose stones, of which the dimensions are about eight feet long, three wide, and eighteen inches high, the "eye of the kiln" being placed opposite to the wind to catch the draft. This is the plan usually adopted, but in some localities they are made longer and narrower. The best kelp ought of course to be made entirely from red weed; however the operators often mix with it any black weed or reeshagh at hand, more especially "Chorda filum" and "Himanthalia lorea." The price of red weed kelp ranges from 3*l.* to 5*l.* a-ton, according to the quantity of iodine it contains, as all lots are examined previous to purchase by the sulphuric acid test.

When writing of iodine, Apjohn says, in reference to its manufacture,† "The burning of the fuci must not be effected at too high a temperature; for if so, much of the iodides will be volatilized, or decomposed by the silex present in the ash. The kelp, broken into small fragments, is digested with boiling water, which dissolves out the soluble salts, amounting on an average to about half its weight. This solution is then boiled down, until a film forms on its surface, and set to crystallize, when sulphate of soda, carbonate of soda, and a good deal of chloride of potassium, are separated. The mother liquor, which still includes the iodides, mixed with chlorides, sulphides, carbonates, sulphites, and hyposulphites, is heated with one-eighth its bulk of oil of vitriol, when carbonic acid, sulphurous acid, and sulphide of hydrogen are disengaged in the gaseous form, and sulphur is set free. Upon standing, the sulphur subsides, and along with it additional crystals of sulphate of soda. The liquid which remains, and in which the

* A wilful fraud committed by the burners on the buyers is the throwing into the mass of kelp, when fluid, lumps of slag procured at the different forges throughout the country; also pounded granite, gravel, &c., all of which add considerably to its weight.

† 'Manual of the Metalloids,' by James Apjohn, M.D., F.R.S., M.R.I.A., &c., &c.

iodine is present, chiefly as hydriodic acid, is then introduced into a large retort, usually made of lead, the beak of which enters the first of a series of three receivers communicating with each other, and finally pulverized peroxide of manganese is added to it through the tubulure. Upon the application of heat, water and sulphate of manganese are formed, and the iodine distils over. The temperature must not rise to 212°; for if it does, chlorine will also be developed, and cause a loss of iodine by converting some of it into chloride. The leaden retort used in this process, and which is of a cylindrical form, is heated through the intervention of sand, and is furnished with two tubulures, through one of which the materials are introduced. The other is placed at about the middle point of the neck of the retort, and serves the purpose of allowing access to the interior of the beak in the event of its becoming plugged with deposited iodine."

The average quantity of red weed kelp sent yearly from the shores of Yar-Connaught is 2500 tons, and the average price per ton is 4*l.*, giving a total of about 10,000*l.* per annum brought into the country.*

If during the spring and summer it is at all favourable weather, and the prices of red weed kelp range from 3*l.* 10*s.* to 4*l.* 10*s.* a-ton, men are enabled to earn from 2*s.* to 3*s.* a-day. The work, however, is very laborious, for, besides the weed driven in on the shores, the kelp manufacturers must supplement the supply naturally brought in by the waves during the summer months, by cutting weed at low-water during spring tides. To do this they go to favourable localities while the tide is high, and the moment the water is low enough, begin operations by one man, with a hook fastened on the end of a long pole, cutting the weed off the rocks at the sea-bottom; whilst another with a pole, having a cross attached, gathers together the weed that floats to the surface, and a woman or boy drags it into the boat. When the tide rises, the boat is rowed to land and the load thrown on the shore for the women and children to carry up and spread out to dry; and as this has to be done twice in the twenty-four hours, while the spring tides last, the work is very arduous. On many of the outlying islands off the coast of Yar-Connaught there are huts which, during the summer months, are inhabited by herds of women, solely for the purpose of carrying up, spreading, and saving the weed thus procured. On such places the kelp is seldom manufactured, but as soon as the weed is saved it is boated to the mainland, or one of the larger islands, and there burned.

* During the year 1867, which was an unprecedented year, some of the kelp fires not being extinguished till Christmas, there were about 3000 tons bought on the coast of Yar-Connaught. These, at an average of 4*l.* a-ton, give a gross sum of 12,000*l.*

We are told that "the red weed kelp is the only really paying trade; nevertheless, some black weed kelp is manufactured, but it is most unproductive, for, on account of the price for soda, it is never worth more than 1*l.* 10*s.* to 2*l.* 10*s.* a-ton, and even at these prices there is not a good demand for it. Previous to the repeal of the salt duty the soap-maker obtained his alkali (soda) from 'Spanish barilla,' or kelp; Yar-Connaught in those days yielded from 3000 to 4000 tons of black weed kelp annually, and Scotland about 20,000 tons per annum; but now from Prussia and Austria vast mineral supplies of alkaline salts are obtained, therefore black weed or reeshagh kelp, chiefly valuable on account of these salts, are scarcely worth making."

Between the former prices for the black weed kelp (about 15*l.* a-ton) and that now paid for the red weed kelp (4*l.* a-ton) there is a vast difference, and seemingly the former ought to have been the most productive trade. Nevertheless, it was not to the manufacturers, unless they were also the proprietors of the land, for as the black weed grows between high and low water mark the cutters of the weed had to pay a high rent to the proprietors of the land, which considerably diminished the profit on the kelp; while all the red weed grows below low-water mark. However, some proprietors charge a small sum for the right to collect the "claddagh" or "seawrack," and others a royalty per ton for leave to burn the kelp on their shores.

As only a trace of the iodine compounds is found in the black weed, why therefore should they occur in the red weed? And from whence does the latter receive them? Neither of these questions has been satisfactorily answered, nor does their importance seem to have been considered. As the "black weed" is daily lying exposed many hours to the atmospheric agencies, possibly this exposure may be unfavourable to the secretion of the iodine producing salts; this suggestion, however, seems to be controverted by none of these compounds occurring in the "reeshagh" —The "red weed" apparently cannot receive the iodine from any particular rock, as this class grows luxuriantly on granite, gneiss schist, limestone, sandstone, slate, and in fact on every rock found on the west coast of Ireland, even on blocks in the gravel, if they are heavy enough to anchor the weed and prevent it being wafted away by the tidal currents. Iodine is rather rare in nature; Apjohn says "Iodine is found in nature only in a state of combination. In 1811 it was discovered by Courtois in kelp, in which it exists united to sodium and potassium; and it has since been found in combination with the same metal in sea-water, several salt springs, and the ashes of the sponge. M. Bussy has detected it in the coal of Allier, and M. Duflos in the coal of Silesia. Lastly, the

iodides of silver and mercury have been met with in Mexico and iodide of zinc in Silesia." In South America salts of iodine occur in some rock masses;* and for this reason some *savans* are favourable to the idea, that the American continent is the source of supply to these shores, the Gulf stream acting as the carrier, and that it is on the shores washed by its waters that the iodine producing fuci principally grow. Against this it might be put forward, that the Gulf stream weed "Sargassum bacciferum" is very poor in iodine. This, however, may be only negative evidence, as there may be richer varieties nourished in the same waters, and the "gulf weed" may be destitute of iodine for somewhat similar reasons to those which prevent the black weed and the reeshagh of Yar-Connaught from secreting it.

If the iodine is brought over by the Gulf stream, naturally it might be expected that it should be best developed near the source, and in places farther removed it ought to be less and less, according to distances; this however does not seem to be the case, for Mr. Steven says, "Iodine although very sparingly developed in sea-water is very generally distributed, and the iodine producing fuci, wherever found, in Ireland, England, Scotland, Channel Islands, France, or Japan, are nearly uniform in composition. In 1857 I analysed some specimens of L. digitata vera and L. digitata stenophylla from Iceland. They were identical in every respect with those found at home; quite as rich in iodine as the best Irish." In none of the published analyses of sea-water that I can find, is the quantity of iodine recorded, it being always mentioned as "a trace." To settle the question whether the Gulf stream is the carrier of it to these shores, it seems necessary that a series of analyses should be made, especially of the waters of the Gulf stream, in all of which the quantity of iodine should be carefully determined. In some medical books there is the vague statement, "A cubic foot of sea-water contains ·005 grain of iodine," but as no authority is given, much reliance cannot be placed on its value.†

* See 'Manual of Mineralogy,' by J. D. Dana, M.A., &c., &c.; and 'Glossary of Mineralogy,' by H. W. Bristow, F.R.S., &c., &c.

† In the *Journal des Connaissances Médicales* (published in November last), there is a brief notice of a method proposed by M. Moride whereby to prepare tinctures from the iodine producing sea-weeds for medicinal purposes. In it are first mentioned the iodine and non-iodine producing weeds, and then the writer goes on to state:—"Sea-weeds containing more chlorine and potash than soda are richer in iodine than in bromine, and the contrary is the case if the plant contains more sulphuric acid and soda than potash." Guided by these general facts, M. Moride conceived the idea of turning these plants to account in their natural state, that is, without subjecting them to a combustion which may modify them considerably, and drive off their most useful volatile ingredients. M. Boussingault and M. Humboldt had stated that in America the inhabitants of the Cordilleras of the Andes were in the habit of using the decoctions of sea-weeds, or else their alcoholic tinctures, in cases of scrofula, wens, and lymphatic tendencies. These liquids are,

In conclusion, it may not be out of place to give a very brief description of the coast, but more especially of those places at which the kelp manufacture is principally carried on. As before mentioned, Yar-Connaught on the west and south-west is indented by numerous fiords, bays, creeks, and cooses. This has led some people to imagine that the name of its western portion, Connemara, is derived from Coum-ne-mara, *i.e.* the "cooms or bays of the sea." This however is incorrect, for, according to the historian O'Fflahertie, the tract was called Conmac, after the name of its prince, and *ne-mara* (of the sea), to distinguish it from his other territories, also called after him, but situated in other counties, such as Conmac-ne-rein in the Co. Longford, Conmac-ne-culy in the Co. Mayo, &c., &c.

Bounding Connemara on the north, and separating it from the county of Mayo, is a remarkable fiord called The Killary, which is over nine miles long, sometimes a quarter, rarely half-a-mile wide, and embosomed in hills that rise abruptly from the water's edge to considerable heights, Moahlrea (the bald king), the highest, being 2688 feet in altitude. South-westward of The Killary, between it and Slyne Head, the south-west point of Yar-Connaught, are other bays, that extend nearly east and west, but none so considerable as The Killary; while eastward of Slyne Head the bays and creeks run north and south, or nearly so, and these latter, combined with east and west straits, form an archipelago between Kilkieran and Greatman's Bays.

Off the coast between the Killary and Slyne Head are numerous islands and sea-rocks, or, as they are locally called, illauns, carricks, and carrigeens, swept by the full force of the Atlantic, therefore most advantageous ground for the growth of the red weed; and on the islands, more especially Innishbofin, also on the main land, but particularly in the neighbourhood of Rinvyle, a considerable quantity of kelp is burned. Hereabouts would not be an unfavourable place for one interested in the manufacture of kelp to examine the process; for at Letterfrack (5 miles from Rinvyle) excellent accommodation can be had at Cassan's Hotel; or, if the observer would like to rough it a little, and see more of the natives, he can take a canoe from Cleggan Bay, and

however, very unpalatable, and have, moreover, a strong smell of the original seaweed; to avoid which M. Moride proceeds as follows:—"The plants, gathered on the rocks on which they grow, are slightly rinsed in fresh water, in order to rid them of the salt water adhering to them, then dried and exposed to the sun, whereby they lose their smell and taste of wrack; after which they are pounded in a mortar and macerated in strongly alcoholized water at a somewhat high temperature. The iodized tincture thus obtained may be used to prepare a medicinal wine or else a syrup with, which will be found useful in all affections for which iodine is prescribed."

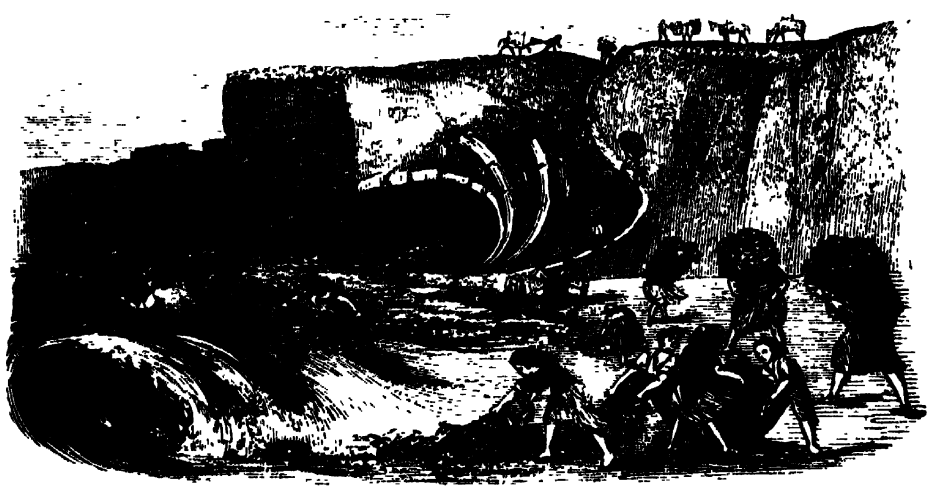
run over to Innishbofin, to remain there until driven off by the kelp smoke. This smoke is very peculiar; it does not ascend like other smoke, but hangs near the surface, creeping along the ground, and lying in heavy clouds in the cooms and hollows among the hills. The natives consider it very wholesome; but strangers generally find it heavy and oppressive, and usually contract a headache from its smell. Visitors might also stop at Mullarky's Hotel in Clifden, from whence they could see the kelp burning to the northward and southward, but the nearest station to the great kelp *dépôts* is the village of Roundstone.

Roundstone, instead of being a miserable village, ought to be one of the principal ports on the west of Ireland, having an excellent harbour, easy of access and sheltered from all winds; moreover, opening into it, are other land-locked harbours, such as Blackhaven, Bertraghbwe Bay, Cashel Harbour, &c. It may be truly said of it, that "it is favoured by God but neglected by man;" and this in a great measure seems due to an absentee proprietary. From this village the kelp fires can be seen on all sides,—out on the islands, in on the bays, north, south, east, and west; and unless there is a good breeze, the horizon will be formed of a heavy cloud of brownish-grey smoke. The great kelp stores are on Kilkieran and Cashel Bays; at the former there is a good pier, alongside which the kelp ships can go; but in Cashel they have to lie out, and the cargo is put on board by boats loaded by girls who carry the blocks of kelp from the store on their backs (see vignette, p. 341), and this exercise so develops them, that they have chests like dray-horses; moreover, it is wonderful what a weight they can carry; some of them thinking nothing of a block two or three hundred-weight.

Roundstone is also a favourable locality from which to visit and explore the beds and tracts of seaweed, the most favourable time being during calm weather and spring tides. The village should be left in the morning with the tide; taking a course eastward or westward as the wind suits; as the tide falls (if the weather is set fair) so will the wind, and by low water the boat ought to be lazily drifting about on a sheet as smooth as a mirror and almost perfectly transparent, so much so that objects, in from twenty to thirty fathoms of water, are quite apparent. Then if an observer leans over the gunwale of his boat he will see the submarine gardens in all their pristine grandeur. If in the deeps of the land-locked bays, there will be groves of the Laminaria bulbosa; or perhaps he may drift in among the cord-like fronds of the Chorda filum, or among the "sea thongs" or Himanthalia lorea. Outside, in the open sea, or, even in the vicinity of the islands, if there are facilities for a strong tide, will be seen groves of the Laminaria digitata tangled up with parasite sea-weeds, or perhaps a mass of the beautiful Alaria

esculenta fringing precipitous rocks. However, one of the most characteristic sights is a low rock in a sandy waste, on which is a garden of L. saccharina or L. phyllitis with their accompanying green, purple, and red parasitic weeds, and in and out through the foliage may be seen little fishes, crustacea and mollusca, creeping, gliding, and sporting.

To the eastward of the previously mentioned archipelago the coast line extends in an east and west direction to Galway town; while on the southward, at the entrance of Galway Bay, lie the Aran Islands. These latter, with a fair breeze, are not more than two or three hours' sail from Roundstone, and are well worthy of a visit, not only on account of the quantity of kelp there manufactured, but also for their peculiar formation, the outcrop of the strata forming long continuous large steps or terraces, and also for the richness of their flora. Besides these natural attractions, anyone interested in archæology will find a good field among the Christian and Prehistoric ruins that exist on all the islands, but more especially on Innishmore.



II. THE LAMBETH OBSERVATORY.

By Robert James Mann, M.D., F.R.A.S.

In the outer courtyard of the Government India Store, situated in the Belvedere Road, Lambeth, and on the bank of the Thames, on the direct line of river-side thoroughfare between the Waterloo and Westminster Bridges, there stands a very complete and pretty little observatory devoted to severe philosophic work, which would certainly not be looked for by the uninitiated in this locality and in these surroundings. The establishment is of modern date, and but little known. Its history, and the reason for its occupying this site, are, however, simple and plain. It rose to its present position when the Indian Store disappeared from the old and traditional ground of Leadenhall Street, and when the Indian administration took westward wing to find its new and more convenient home in Downing Street. At that time it was thought meet to provide a lodgment for the store department nearer to head-quarters, and a very commodious building was accordingly erected in the Belvedere Road, and opened in the month of February, 1864. The general purpose of this building is to furnish a temporary warehouse in which all articles destined for the military, medical, and educational branches of the Indian service may be received, examined, and packed for shipment.

A considerable number of scientific instruments of various classes have for some time been annually sent out for use in India under the auspices of the Indian Government. In the old days of the Indian administration, the custom in regard to such instruments was that a sealed pattern of each kind of instrument in occasional demand was kept in the store department attached to the establishment in Leadenhall Street, and whenever a supply was required for service in India, the instrument makers of England were invited to send tenders of the prices at which they would undertake to furnish the required articles, constructed in exact imitation of the sealed patterns. In general practice, the maker who offered *to supply at the lowest price* received the commission; and when it was executed the instruments were sent in to the store, superficially compared with the pattern to see that they were of the kind that had been ordered, and were then shipped off to India, and the transaction was held to be complete.

In this proceeding the real excellence of the instrument, its real fitness for the satisfactory performance of the work it was designed to accomplish, was altogether left to the accident of the way in which the maker might be able or willing to perform his

share of the bargain. It was assumed that if the implements looked like the pattern, it would be all that could be desired, and if by any accident it was discovered that it was not all that was desired, the responsibility was conceived to rest upon the shoulders of the tradesman who had thus badly executed his order. This system was obviously not likely to prove satisfactory where the delicate and exact work of observational science was concerned. In the first place, the sealed pattern assumed a perfection in instrumental construction which will not be obtained after many more centuries have been consumed in unceasing improvement; and in a sense also ordained that Indian science should operate with obsolete instruments, instead of with the best that could be produced in the existing state of cosntructive art. And in the next place, the best makers who had a reputation for excellence to sustain were more or less excluded from the Indian orders because they were expected to compete with men who looked to profit out of low prices, rather than to furnish excellence of work.

It happened while matters were in this position that Colonel Strange, who was the originator, and is now the life and manager of the Indian Store Observatory, was requested to examine a quantity of instruments that had been sent to England for repair, before they were again shipped off for India. In performing this duty, he was constrained to urge that the greater part of these instruments, about which a considerable expenditure had been incurred, were really of an obsolete form and useless for practical work; and to recommend that the whole should be sold for anything that could be made of them, rather than that the serious injury should be inflicted on officers in India of giving them tools that could only furnish erroneous and misleading observations.

The instruments accordingly were withdrawn from the service, and the incident had also a further and more practical result. It opened the eyes of the authorities to the need of a different mode of procedure, and arrangements were forthwith entered upon to secure at least a standard measure of excellence in all instruments sent out to India. At first Colonel Strange was commissioned to examine batches of instruments of various kinds fitfully, as they were prepared for shipment; but after he had pointed out that this could only be serviceable when means of efficient examination were available, he was requested to submit a recommendation as to the appliances which were requisite for the scrutiny. The recommendation was that a fixed observatory should be established for the work, and a plan of the character and instrumental furniture of this testing observatory was suggested. The plan was formally and officially examined by the Astronomer Royal, the President of the Royal Society, and the Director of the Ordnance

Survey; and these practical authorities pronounced that the proposal was sound in principle, and likely to be efficient in operation. The order was then issued that the observatory should be constructed; and the construction, and subsequent management of the establishment, were placed in the hands of the designer, Colonel Strange, who in addition to a natural taste for, and capabilities of, dealing with delicate and fine mechanism, had enjoyed the field experience of thirteen years of service upon the great trigonometrical survey of India.

The first matter that had to be decided in connection with this design was the place where the fixed observatory could be planted. Up to this time all instrumental examinations had been made in the old building that had been used as the Indian store, and that stood opposite to the ancient Company's "House" in Leadenhall Street. It therefore was deemed only natural that the instruments should follow the store, and that the observatory should be planted on the ground acquired by the department in Lambeth; the site was obviously not the best in the world for the purpose, but as no other available position could on the instant be fixed upon, it was ultimately resolved to do the best that could be done in connection with the Lambeth store, and the existing observatory was commenced in the year 1865.

The earliest proceeding was necessarily to neutralize the natural unfitness of the ground and position for exact instrumental work, so far as this could be done. This has been most admirably and most efficiently accomplished, and as follows:—First, twelve iron screw-shod piles with the widest part of the spiral thread 2 feet in diameter were wormed into the gravel, which here lies 24 feet below the surface of the ground. Broad heads of cast iron were next keyed upon the top of the piles. Thick slabs of flag-stone were then laid upon the pile-heads, and the space beneath filled in with concrete cement to the depth of about three feet. A circular platform of brickwork was finally constructed upon the flag-stones, and upon this, two semicircular segments of wall were reared round the circumference, and a solid pedestal of masonry was erected in the centre. This circle of wall, cut by two gaps at opposite points of the circle, and this enclosed central pedestal are the objects which now form the visible base of the observatory, and which carry the chief instruments employed in the scrutiny. A wooden platform, or floor, between the circular wall and the central pillar, to which access is obtained through the gaps, is carried upon beams that are supported from beyond the system of pile-work, and is carefully isolated from all mechanical connection with the piled foundation, so that the observer moves about upon this floor without effecting any disturbance in the position of the instruments carried upon the walls and the pedestal. This method of securing

a firm foundation upon so unpromising a base as a river-bank shaken by the incessant rolling of heavy carts, has been found to be very efficient, if not practically perfect. Since the first setting of the masonry of the platform not the slighest permanent change has occurred in the bearings of the instruments. Passing carts communicate a slight transient vibration for the moment, which, however, has no other inconvenience than causing an occasional brief suspension of observation.

Upon entering this little model testing observatory of the Indian store, then, the general aspect is that of a square room with a raised circular platform in its centre, reached by a small flight of stairs. A broad solid wall-like rim, breast high, and included within an outer suspended pathway for the observer, runs round the platform, and affords a convenient resting-place for instrumental appliances of various kinds. In the midst of this circle a flat-topped pillar forms the bed upon which the instrument to be tried is placed by the examiner.

Overhead the broad glass roof, with the uninterrupted space of clear sky, indicates that the star-rulers of the night can be appealed to whenever such higher and more refined arbitration is deemed desirable.

One of the most important objects that is attempted in this observatory is the examination of the exactness of graduated circles that are designed for horizontal measurement. Unless these circles do measure equal and true degrees in all their parts, it is obvious that the angular intervals recorded from them are not worth the paper upon which the records are inscribed. To accomplish this end four horizontal tubes, called collimators, have been placed on different parts of the circular wall, so that an observer can contemplate each of them from the telescope attached to the instrument under trial. These collimators are in reality only so many fixed and immovable points, occupying for the time known, or more properly ascertainable, positions on the great wall-circle, and therefore including also known, or ascertainable, angular intervals between them. The exact reference-points, or virtual centres in these collimator tubes—"the marks to be collimated or aimed at" —are of a varied character. In one there is a system of diagonally crossing spider-threads, and in another of horizontally and vertically crossing threads, forming the reference-points by their intersection. In yet another tube an artificially fixed star is formed by throwing gaslight through an exquisitely minute aperture, which has its own image reproduced in the focus of a convex lens, so contrived as to fall only one-fifth of an inch from the curved surface of the glass, a proceeding which practically reduces the image of the simulated star to the very smallest dimension to which it is possible to compress it. The four reference-points, or collimators, are,

for convenience sake, so placed upon the wall that the angular intervals included between them on the circular arc are respectively 30, 60, 120, and 150 degrees. This arrangement, by varying the pairs of collimators used, allows twelve different angles to be tested. The test, in plain language, is simply reading these angles off as they are given by the circles of the instruments, and then shifting round the circles again and again, so that exactly the same work is performed in succession by different portions of the same graduated rim. If the graduations of the circle are correct and trustworthy, the angles read off between any given pair of collimators will obviously always have the same value whatever portion of the circle be employed in the reading. This test is a very accurate and a very severe one. The slightest inexactness and failure in the mechanical work at once becomes glaringly obvious, and can be estimated as a question of amount as well as of fact. In practice the process is repeated with each instrument on successive occasions, to test permanence as well as exactness of construction and performance;—to see that there are no weak and yielding points, or shifting screws, or attachments, involved in the structure. If the reference-points were simply so many fixed spots, established upon the circular wall, it would be necessary that every graduated circle placed under examination should be truly centred upon one point with the most refined exactness. This necessity is practically avoided by placing the reference-points in tubes behind, or beyond, curved lenses of glass, which have the useful property of always sending parallel rays to the telescope of the tried instrument, and therefore always securing the invariability of each angular instrument however the centre of the reading circle may lie. Colonel Strange has satisfied himself by actual trial that the centre of a graduated circle, or arc, may be shifted a fifth of an inch without making any appreciable alteration in the value of the angles read. It is this especial virtue which converts a mere visible fixed point of reference into what is technically known as the "collimator."

The testing of *vertical* circles is a far more difficult piece of business than the trial of horizontal ones, for this reason—in vertical circles the telescope which is employed in making each observation is rigidly connected with some unalterable radius of the circle, and any given angle included between reference-points cannot therefore be applied over and over again to different portions of the circle. This however is not of very much moment, because the vertical and horizontal circles of any given maker are turned out by the same graduating instrument, and if the horizontal circle is found to be graduated correctly, the vertical circle may with some confidence be assumed to be of the same excellence. In the case of the larger and more important instruments the examination is rigidly carried out by observing standard Greenwich stars as they

pass over the meridian. The angular intervals lying between the culminating points of these standard stars are most accurately determined by multiplied observations at established observatories; therefore all that is necessary, is to see that the graduations of the circles indicate the precise a gular intervals that they ought to show for the stars that are employed in the test. There is, however, one appendage to all vertical circles that is of a somewhat slippery and suspicious character, but that is nevertheless at the bottom of all correct indication, and must therefore be made the subject of scrutiny. This is the level which is used to give the horizontal point from which vertical elevation is reckoned. One portion of the internal surface of the glass tube used in the construction of the level is so ground that it just departs from a straight direction in the line of length, so far as to give the air-bubble imprisoned on the spirit an inclination to rest in the centre. But this surface requires to be graduated so that the bubble travels over exactly the same linear space on the graduation, for every equal angular change in the elevation of one of the ends of the tube. To ascertain whether the level is so made that this actually occurs, it is placed upon a cradle of iron, and a delicate screw with a divided head is turned hundredths of parts of a revolution at a time to raise or depress one end of the cradle. If the level is well made, the bubble travels one mark of the graduation for every hundredth part of a turn of each thread of the screw. This appliance of test is so delicate, that if the finger and thumb are placed gently against opposite sides of the bearer, the bubble moves from its place under the expansion caused by the mere warmth of the living contact; or if, again, the hand be pressed firmly on the two-inch-thick slab of slate that carries the instrument, the flexure of the seemingly inflexible slate is immediately made apparent by the travelling of the bubble.

The optical performance of the telescopes of small surveying instruments is tried by fixing a card, which has a series of lines clearly traced upon it, some the fiftieth, some the seventy-fifth, and some the hundredth of an inch asunder, 25 feet away; telescopes of different degrees of power should render the divisions of the one or other of these series distinctly visible at this distance. The lines which are the hundredth of an inch asunder subtend seven seconds of angular measure at the distance of 25 feet; that is to say, a telescope which can show the closest lines as distinct visible objects at the distance of 25 feet, will be capable of clearly discerning an actual object of even less than seven seconds of size. The card containing the tracing of these lines also carries the exact representation of the scale of the surveyor's levelling staff as it would be seen at a distance of five chains and ten chains. These scales are produced in most exquisite clearness and perfection by

photography. They are printed from a standard negative plate preserved in the observatory, so that identically the same test can be supplied in any number of instances where instrument makers may wish to avail themselves of it.

There are two clocks in the observatory, of which one marks mean, and the other sidereal time. The mean time clock is in immediate and sympathetic connection with the great central time standard of the Greenwich Observatory, the communication being effected by electrical agency. The bob of the clock-pendulum is a hollow coil of copper wire, embracing, without contact, a selection of permanent magnets. The ends of the coil pass away, and are ultimately connected with the Greenwich clock, which supplies through the wire a current of electricity at every alternate second. The movement of the clock-train is maintained in the usual way by a weight; but the accuracy of the going is secured by the magnetic contrivance. Every alternate second of true mean time, the swinging magnet receives a slight accelerating pull from the coil, virtually converted into a magnet itself for the instant. A tell-tale magnetized needle marks the seconds by alternate sway, but always stands still at the first second of every hour by the Greenwich time, and starts its vibration again at the fourth second after the hour. This most elegant and efficient application of electro-magnetism is due to the ingenuity of Mr. Jones, station-master at Chester, and is known as "Jones's Patent Controlled Pendulum."

Meteorological instruments, in every variety, are tested at this observatory; the standard barometer has been carefully compared with the standards of both Kew and Greenwich. The divisions of the scale are also very accurately compared with a measure of length finely marked into hundredths of an inch, taken primarily from the preserved national standard. Aneroids are tried by a very ingenious contrivance. A batch of the instruments is placed in a glass-covered cylindrical reservoir, which is connected with the receiver of an air-pump, in such a way that the channel of communication is crossed by a diaphragm of porous porcelain. The receiver of the air-pump is then exhausted to a certain degree, and the exhaustion of the reservoir containing the aneroids goes on through the porous diaphragm very slowly, in order to imitate the action of the instrument when used to measure mountain ascents. The exhaustion takes place at the rate of about one inch of pressure per hour, and at every half-inch of change the instrument is compared with an accurate mercurial barometer forming part of the apparatus.

Thermometers are proved in the freezing and boiling points by immersion in melting ice and in steam; and a certain number of intermediate points of temperature are also verified, by comparison in water, with standards authenticated at Greenwich and Kew. With

the existing appliances this comparison is carried, not without difficulty, up to 92 degrees of Fahrenheit. It is deemed most desirable, where service in India is contemplated, nevertheless to extend the examination of intermediate points up to 120 degrees. But this is a very delicate and difficult task. Whenever there is more than 30 degrees between the natural temperature of the air and the temperature of the water in which the instruments are immersed, the cooling of the water goes on so rapidly and so irregularly that instruments immersed in the liquid are really differently affected in different places. A remedy for this imperfection is under consideration, and it is intended that means shall be provided, as opportunity allows, for testing large numbers of thermometers at a time in which the uniform diffusion of temperatures quite up to 120 degrees is artificially provided for in a vessel surrounded by a large body of heated and constantly moving water, the heat of which is to be retained by a jacket, or coating, of very slowly conducting material. The freezing points of four standard thermometers, which, after all, are the sole reliable and unalterable elements, are examined once a-year to guard against error from the contraction of the bulbs and other slow changes of constituent material.

The instrument which occupies the place of scrutiny in this testing observatory at the present time is one of a very magnificent set that has been for some time preparing for use at the central stations of the great Trigonometrical Survey of India. It is a large theodolite (one of a pair), with a three feet vertical, and a two feet horizontal, circle. Its companions for this service, of which specimens stand in reserve in other parts of the observatory, are a pair of transit instruments, a pair of zenith sectors, and a pair of chronographs. In many particulars these noble instruments are entirely unique, and deserve a much more precise and particular description than can here be given, in consequence of limitation of space.

It may, however, be nevertheless briefly explained in regard to them, that each theodolite, which is designed mainly for determining the angles of large triangles through the instrumentality of heliotrope flashes given by mirrors from twelve to forty miles away, has a frame chiefly composed of aluminium bronze, which is three times as rigid as a similar structure of gun-metal, and therefore confers twice the rigidity, in two-thirds of the weight that gun-metal can furnish. The large circle bearing the graduations for fine work is protected by an outer guard-ring which takes all the strain, and serves also to equalize temperature. The tangent screw is made, by the application of a peculiar spring, to exert an invariable force. The adjusting levels are of great delicacy, and the telescope is furnished with two eye-pieces, one with a horizontal

and the other with a vertical set of micrometers. The foot screws press against flat arms of metal, which are a fixed and integral part of the stand, to obviate lateral *wriggle.*

The transit instrument, which will fix the longitude of the principal stations, has an adjustment for the bearings of the pivots, because the plan, now universally adopted in large instruments for fixed observatories, of banishing entirely these adjustments, could not be conveniently adopted in peripatetic instruments, that must be moved from station to station. Each pivot is carried on a triangle of iron resting on three screws, furnishing means of rough adjustment for horizontality. The connection of the pivot with the triangle is, however, managed through a kind of ball and socket intervention, in which the socket or cup is attached to the triangle, while the broad convex spherical surface representing the ball is the bottom of the metallic piece which supports the cylindrical bearing of the pivot. One pivot allows of vertical, and the other of horizontal adjustment; in both cases the ball and socket adapting itself with ease and exactness to the movement effected. Four levels for securing horizontality, *hang from spindles mounted transversely upon the centre-piece of the telescope* itself, and in such a way as to remain in free and constant adjustment during the rotation of the telescope upon its transverse axis.

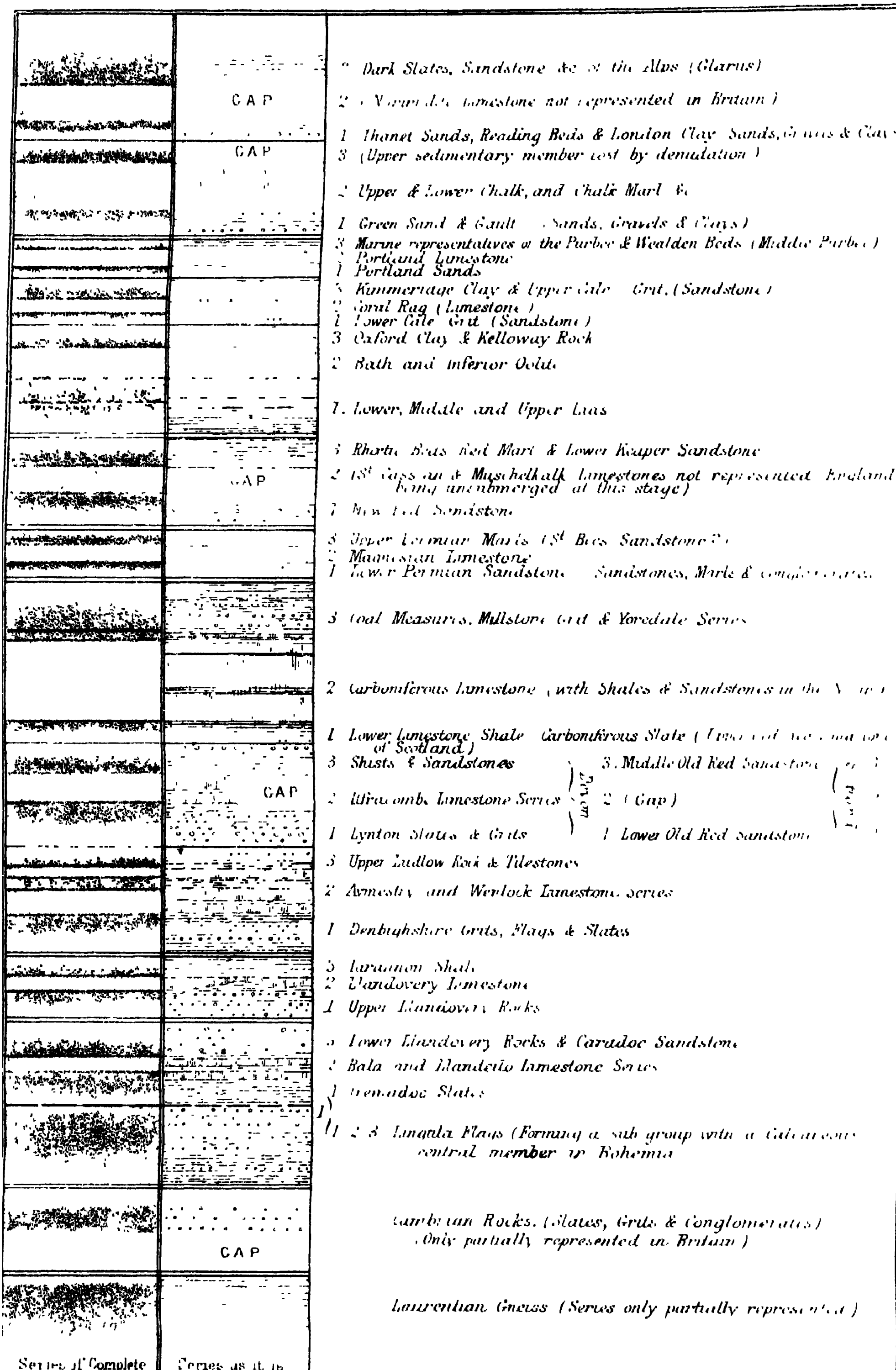
The chronographs, or time-registers, prepared to make the transit observations to be recorded upon paper by electrical agency, are chiefly remarkable for a most exquisite contrivance for securing uniformity and exactness of movement, which is the invention of M. Foucault, of the Imperial Observatory of Paris. A barrel is carried round every two minutes by a tram of clock-wheels, and two companion points so press upon paper stretched over the barrel, and saturated with an appropriate chemical agent, as to allow a deep purple dot to be impressed on the paper every time the pendulum of a clock sends a momentary current of electricity through one point, which in practice is at the completion of each second, while the finger of the observer does the same thing at will with the other point, to register the time of the observation, so interpolated between the seconds-dots. The movement of the barrel is regulated to rate and uniformity—first, by a fly-wheel, something like a miniature paddle-wheel, which revolves rapidly in a hollow case furnished with a peripheral slit, which can be enlarged or diminished, to secure more or less aërial resistance, as it may be desired. But in addition to this, the double balls of the ordinary Watts' steam-governor are attached in such a way that when they diverge from each other with too rapid motion, they lift the weight of a lever-mounted counterpoise by rods coming down from the middle of the diverging arms. The more rapidly the balls revolve the more load they take upon themselves

from the lever-weight as a retarding influence. The weight of the lever hangs, for this purpose, perpendicularly under a suspending pivot, and therefore in repose and out of use, when the gyration of the governor is not too fast and the drag is not wanted. It only comes into effective operation when it is drawn out sideways by the too rapidly revolving gove: ıor acting upon a tail-like lever arm above.

The zenith sector, which is to give the latitude of the principal stations, is of the same optical and measuring power as the zenith sector of the Royal Observatory, but on account of its peculiar construction, weighs only $595\frac{1}{8}$ lbs., while the Greenwich sector weighs 1140 lbs. It consists essentially of a vertical pillar, carrying a transverse axis, which has, in place of a wheel, two crossing sets of radii, of which one pair is in reality the telescope, and the other pair the arm of the sectors, read by four microscopes, and each including an arc of 45 degrees. The sectors are free from all mechanical strain, and only *looked at* by the microscopes. In observing, the position of a star nearly on the meridian and within 15 degrees of the zenith is noted, and the graduations of the sectors are read off. The instrument is then turned half round on its vertical axis, the star brought into the telescope field again, and the sectors once more read off. The angular interval of the arc comprised between the two readings is then necessarily twice the zenith distance of the star; and if the star is a standard star with known and determined polar distance, this at once becomes an indication of the latitude of the place whence the star is observed. The zenith distance of the star gives the height of the pole of the heavens from the horizon, and this involves the angular distance of the place from the earth's pole; or, in other words, its latitude. The star is referred to its exact place on the meridian, as it has to be observed in succession immediately before and immediately after its culmination to allow for the reversal of the instrument, by a micrometer wire adjusted in the field of vision. A series of very beautiful and perfect mechanical expedients are adopted to combine in this instrument the two opposite excellences of lightness and firmness; in other words, to enable the instrument to be readily transported from station to station, and yet to make it of high astronomical value when in use. The entire series of these instruments has been in hand and under examination during seven years, and within that period they have undergone continual and frequent modifications under the suggestions of the tests applied, and are therefore in a fair way of presenting in the end a measure of excellence which could not have been attained without the exact and refined appliances of scrutiny which the establishment of this observatory affords. Indeed, no better witnesses than these instruments could be called in support of the argument urged by Colonel

Strange, at the last session of the British Association for the Advancement of Science, for the institution of increased facilities for prosecuting research into the physical conditions and laws of material nature, and for improving man's dealings with those mighty, though subtle powers.

One hundred different kinds of instruments are tested in this useful and unpretending little observatory at Lambeth, and the number of individual instruments examined each year now amounts to about four thousand. The final result of the establishment of the observatory has, in Colonel Strange's opinion, amply justified the proceeding and established its need. The Colonel, to use his own words in speaking of the matter, considers that "the instruments now sent out for use in India are to their predecessors very much what the civilized man is to the rude savage." The practice in connection with the testing observatory is that orders for the different kinds of instruments required are given to the best makers at prices which enable the highest amount of mechanical excellence to be furnished, and which justify the exaction of the best possible workmanship. No trammels of "patterns" are incurred, and the freest scope is left for the adoption of rapidly progressing improvement in mechanical art. The maker who receives the commission goes to the observatory to ascertain exactly what is required of him. This often leads to a lengthened discussion, and extended deliberation before the work is commenced. The price is estimated by anticipation, and submitted to the inspector, and if in his opinion the estimate is reasonable the work is proceeded with. The instrument on completion is sent to the observatory on the understanding that the right of rejection has been reserved either provisionally or unconditionally, and that in either case any such decision is to be held final. Responsibility for excellence of work is thus transferred from a necessarily interested maker to an independent and specially qualified judge. Makers are continually invited to avail themselves of the exceptionally excellent facilities of the observatory in testing their own work, and are so incited to renewed efforts to obviate imperfections. In this way the most sagacious and capable of the profession come to see at a glance that their performance is made the object of examination by an impartial tribunal that only concerns itself with facts, and has nothing to do with hesitating and loose opinion, and that therefore the Lambeth Observatory constitutes a court of final appeal whose decisions must be held to be beyond further question or dispute.



Dark Slates, Sandstone &c. of the Alps (Glarus)
CAP
2 (Nummulitic limestone not represented in Britain)
1 Thanet Sands, Reading Beds & London Clay Sands, Gravels & Clays
CAP
3 (Upper sedimentary member lost by denudation)
2 Upper & Lower Chalk, and Chalk Marl &c.
1 Green Sand & Gault Sands, Gravels & Clays)
3 Marine representatives of the Purbeck & Wealden Beds (Middle Purbeck)
2 Portland Limestone
1 Portland Sands
3 Kimmeridge Clay & Upper Calc Grit, (Sandstone)
2 Coral Rag (Limestone)
1 Lower Calc Grit (Sandstone)
3 Oxford Clay & Kelloway Rock
2 Bath and Inferior Oolite
1. Lower, Middle and Upper Lias
3 Rhaetic Beds Red Marl & Lower Keuper Sandstone
2 (St Cassian & Muschelkalk Limestones not represented England being unsubmerged at this stage)
CAP
1 New Red Sandstone
3 Upper Permian Marls (St Bees Sandstone?)
2 Magnesian Limestone
1 Lower Permian Sandstone Sandstones, Marls & Conglomerates
3 Coal Measures, Millstone Grit & Yoredale Series
2 Carboniferous Limestone (with Shales & Sandstones in the North)
1 Lower Limestone Shale Carboniferous Slate (Limestones of Scotland)
3 Shists & Sandstones
2 Ilfracombe Limestone Series
CAP
1 Lynton Slates & Grits
Devon
3. Middle Old Red Sandstone
2 (Gap)
1 Lower Old Red Sandstone
3 Upper Ludlow Rock & Tilestones
2 Aymestry and Wenlock Limestone Series
1 Denbighshire Grits, Flags & Slates
3 Tarannon Shale
2 Llandovery Limestone
1 Upper Llandovery Rocks
3 Lower Llandovery Rocks & Caradoc Sandstone
2 Bala and Llandeilo Limestone Series
1 Tremadoc Slates
1 2 3 Lingula Flags (Forming a sub group with a Calcareous central member in Bohemia
Cambrian Rocks. (Slates, Grits & Conglomerates) (Only partially represented in Britain)
CAP
Laurentian Gneiss (Series only partially represented)
Series if Complete
Series as it is

III. ON A TERNARY GEOLOGICAL CLASSIFICATION.

By Edward Hull, M.A., F.R.S.

The views I am about to advance in the following paper are the result of observation and reflection extending over several years, at first somewhat vague, but now taking a definite form and direction. They are advanced with some diffidence, and I am aware that exception will be taken to some of my conclusions as being contrary to general acceptation. Such objections, as far as they have occurred to myself, have been well weighed. It must be left to time to determine whether there is sufficient ground for believing in a general law of development of geological formations, depending on the mutual relations of organic and inorganic agencies; in the meanwhile I content myself with the endeavour to point out the evidences of such a law as bearing more especially on the arrangement of the British strata, leaving to a possible future the attempt to deal with those of foreign countries.

The tendency of several groups of strata to assume a threefold arrangement has not escaped the notice of geologists. Sir Roderick Murchison has very strongly insisted on it in reference to the "Permian system," both in Britain and the Continent. The Trias is (as its name denotes) an evident example, as is also the great Carboniferous series both of Britain and America. In each of these cases we have a central calcareous member interposed between an upper and lower member composed of sandy or muddy materials, to which the term "sedimentary" may be applied. Now, when we find in the case of three great groups following each other in order of time, and lying on the margins of the grand divisional line which marks the boundary of the Palæozoic and Mesozoic series, a similar order of sequence and of mineral composition, we may well pause and inquire whether there must not be some great principle lying below the surface, impelling or guiding the operations of nature in the direction of geological cycles, reproducing themselves at distant intervals, and indicated by the mineral characters of the rocks. It may seem a hazardous assertion that the history of a natural system (or group) of strata is analogous to that of a nation, or of man himself individually; that it has its beginning, its prime, and its decline; and that each of these stages has its representation. Yet the evidence in favour of this view is very strong, and seems to fall in with the course of physical events which we know to have occurred at successive geological periods. This view of the natural grouping of strata forced itself on my mind in 1862, when treating in the pages of the 'Journal of the Geological Society of London' on the relative distribution of the "calcareous" and "sedimentary"

strata of the Carboniferous rocks of Britain.* I there remarked that "we cannot fail to have observed that many groups of strata have a tendency to arrange themselves into threefold divisions, the upper and lower being composed of sandstones and shales, the middle of limestone."

As the subject was foreign to the question before me at the time, except as bearing on the Carboniferous series, I did not pursue it; but in a paper more recently read before the Geological Society of Glasgow (in 1867), and published in their Transactions,† on another branch of the subject, I entered rather more fully into the discussion of this question, and ventured to state certain general principles as bearing on the operations of nature during past geological periods, which I venture to repeat here—

1st. *That in any formation composed of contemporaneous calcareous and sedimentary strata, these two classes of rocks must have had their sources in opposite centres or lines of distribution.*

2nd. *That in the same formation, consisting of calcareous and sedimentary materials, the maximum development of each class has been reached in positions relatively opposite to each other.*

In that paper I also proposed a threefold arrangement of the British formations from the Upper Silurian to the Tertiary inclusive. Since then I find that somewhat similar views have forced themselves on the mind of a distinguished geologist, Dr. Dawson, F.R.S., of Montreal, who, in his elaborate paper on "The Conditions of Distribution of Coal as illustrated by the Coal-formation of Nova Scotia," arranges the Carboniferous series of that country under three heads corresponding to those of Great Britain, and formed under similar physical conditions.

These alternations lead Dr. Dawson to the suggestion of "Geological Cycles" for the Palæozoic rocks of America, but he adopts a fourfold classification, though, as it seems to me, a threefold is a more natural one, at least as regards the Carboniferous group. The following is Dr. Dawson's quaternary classification, which he has more recently incorporated in his work, 'Acadian Geology:' ‡—

* Vol. xviii., p. 134. † Vol. iii., part 1.

‡ Although Dr. Dawson's paper was published more recently than my own already alluded to, it seems to have escaped his observation. This fact is satisfactory, as showing that on opposite sides of the Atlantic there is evidence of a natural order of arrangement according to geological cycles, and indicated by the mineral character of the strata. With regard, however, to the arrangement proposed by Dr. Dawson, it appears to me that a threefold classification might equally well be adopted, at least in the case of the Carboniferous series, and that there are no good grounds for dissevering the third and fourth stages. In the case of the other groups, it is a question for further inquiry whether the series is not also capable of arrangement according to a ternary system; but in order to determine this point, a fuller knowledge than I possess of the relative importance of the several members of the series, and their relations to each other over the whole area would be required.

TABULAR VIEW OF CYCLES IN THE PALÆOZOIC AGE IN EASTERN AMERICA.

CHARACTER OF GROUP.	LOWER SILURIAN.	UPPER SILURIAN.	DEVONIAN.	CARBONIFEROUS.
Shallow subsiding marine area.	Hudson-River group.	Lower Helderberg group.	Chemung group.	Upper Coal-formation.
Elevation followed by slow subsidences.	Utica shale.	Salina group.	Hamilton group.	Coal-measures.
Marine conditions; formation of limestones.	Trenton, Black-River, and Chazy limestones.	Niagara and Clinton limestones.	Coniferous limestones.	Lower Carboniferous limestone.
Subsidence; disturbances; deposition of coarse sediment.	Potsdam and Calciferous sandstones.	Oneida and Medina sandstones.	Oriskany sandstone.	Lower Coal-measures and conglomerates.

I now proceed to explain the principles upon which a threefold classification of strata with a calcareous central member is based; in order to which a knowledge of the origin of marine limestones is essential.

Marine Limestones.—And, first, this classification depends on the distinctive character of marine limestones as compared with all other stratified deposits. While conglomerates, sandstones, shales, and clays are essentially mechanical in their mode of formation, limestones (except under peculiar circumstances) are essentially organic. This, indeed, is the view of many of our most distinguished naturalists, and amongst others of our great authority on chemical geology, M. Bischof. This author states that the quantity of free carbonic acid gas contained in the sea is five times as much as is necessary to keep in a fluid state the quantity of carbonate of lime to be found in it. From this he draws the conclusion that it is impossible for any carbonate of lime to be precipitated in a solid form at the bottom of the sea by chemical action alone, and as the quantity is extremely small in the open sea, it is difficult to conceive that this can be effected otherwise than by vital agencies.*

This is a view, indeed, that can scarcely be questioned, and which is supported by reference to the composition of the limestones themselves. If, indeed, we might have looked for illustrations of this class of rocks as having been formed independently of organic agencies, it would have been amongst the most ancient formations of the globe. But what has been the case? Far down below the "Primordial zone"—in strata more ancient by at least two geologic cycles than those lately supposed to contain the first traces of animal life—we find a series of serpentinous limestones, of the real organic origin of which, the microscope has not left us in doubt. The researches of Sir William Logan and his colleagues of the Geological Survey of Canada, followed by other naturalists, have demonstrated that even the oldest known limestones on the surface of the globe owe their origin to the *Eozoon*, an animal considered by Dr. Dawson to be a Foraminifer.

* 'Chemical Geology.'

It can scarcely be considered an argument against the organic origin of marine limestones, that they frequently exhibit no trace of organic structure. Limestones undergo metamorphism sometimes during their very formation in the open sea; how much more so after having been subjected to the action of heat, pressure, percolation of water, and other agencies, known and unknown, acting within the crust of the earth. On this subject the testimony of Mr. J. B. Jukes may be considered conclusive. Speaking of the rapid change which coral reefs undergo as observed by him during his voyage in H.M. ship 'Fly,' he says, "The surface of a reef when exposed at low water is composed of solid-looking stone, which is often capable of being split up and lifted into slabs bearing no small resemblance to some of our oldest limestones. These slabs, when split up, are frequently found to have a semicrystalline structure, by which the forms and the organic structure of the corals and shells are more or less obliterated."

As to the origin of the lime in the sea-water, that is a question immaterial to my present purpose, which is to show the essential distinction between the great group of calcareous formations in all geologic ages, and the strictly mechanical strata with which they are associated.* But before passing to the discussion regarding the relations of this latter class of strata, let us notice the several varieties of marine animals which have chiefly contributed to the formation of limestones, and which we may call "the limestone builders."

Limestone Builders.—At first sight it might be supposed that nearly all invertebrate marine animals having stony skeletons, or shells, contributed proportionally to the formation of limestones. But when we come to examine the classes of animals which in our own day have contributed to the formation of the calcareous ooze of the Atlantic, or the limestone reefs of the Pacific; and extending our researches back into geologic times, examine the structure of our great limestone masses, we soon perceive that the chief limestone builders have been animals of comparatively low organization, and embrace but a small portion of the sub-kingdom of *invertebrata.* They consist for the most part of the calcareous shells of *Foraminifera,* associated with the siliceous shields of *Polycystina,* forming not only the present calcareous ooze of the Atlantic bed but also a large proportion of the Secondary and Tertiary limestones. Next come the polyps or corals (*Actinozoa* or *Anthozoa*), ranging downwards from Palæozoic times to the present day, and entering largely into the composition of Silurian, Carboniferous, and Jurassic limestones. Then the *Bryozoa* or *Polyzoa,* largely distributed in the

* The reader will find the question as to the origin of lime in the sea-water, and the *apparent* increase of calcareous rocks in more recent times, discussed in Lyell's 'Principles of Geology,' 10th edit., p. 608.

Carboniferous, Permian, and Jurassic limestones. With reference to this order I may here quote an observation of Professor Rupert Jones, who says,* "Some of the dark-grey Carboniferous limestone is as largely composed of *Fenestellæ*, &c., as the Permian limestone of Durham and Germany often is. One of the best instances of Polyzoan limestone (representing the Faxoe and Maestrich chalk) is the great white limestone of South Australia traversed by the Murray river, and which occurs again, as it were, in New Zealand as the Ototara limestone of Otago, &c."

The Echinodermata, as represented principally by the *Crinoideæ*, have contributed very largely to the formation of the limestones of the Carboniferous period, as well as, though in a smaller degree, of those of the Upper Silurian and Jurassic periods. As the late Professor Edward Forbes remarks, "Formerly they were amongst the most numerous of the ocean's inhabitants,—so numerous that the remains of the skeletons constitute great tracts of the dry land as it now appears. For miles and miles we may walk over the stony fragments of the Crinoideæ; fragments which were once built up in animated forms, encased in living flesh, and obeying the will of creatures amongst the loveliest of the inhabitants of the ocean."† The *Crustacea*, as represented by the diminutive *Entomostraca*, took a very important part in the formation of limestones, as abundantly proved by Prof. Rupert Jones and Dr. H. B. Holl.‡ In the "Caradoc Bala" limestone of the Chair of Kildare they largely occur, and, with other Palæozoic forms, are placed by these authors under the generic name of "*Primitiæ*."§ Prof. R. Jones states, "The Caradoc Bala limestone of Kildare swarms with them; so does that of Keisley in Westmoreland; so do the Upper Silurian limestones (Wenlock chiefly) near Malvern, as shown by Dr. Holl; so does the Upper Silurian limestone of Gothland remarkably. The Dudley limestone is rich with *Beyrichiæ*; the Upper Silurian limestone of Beechy Island in the Arctic regions and the Lower Silurian limestones of Canada (in the Calciferous and Trenton groups) either abound with, or are made up of, them. In the Lower Helderberg group of the New York State (Upper Silurian) there is a *Leperditia* limestone, and in Russia and Oesel Isle, Leperditiæ make up at least one of the limestones."‖ Prof. R. Jones and Mr. J. W. Kirkby, together with Mr. John Young and other authors, have also shown that these little crustaceans abound in the calcareous beds of the lower Carboniferous series of Scotland.¶ The part in nature played

* In a letter to the author (1868).
† 'British Star-fishes,' p. 2.
‡ 'Annals and Mag. Nat. Hist.,' 1865-8.
§ "On Palæozoic Bivalved Entomostraca, &c.," ibid., July, 1868.
‖ Letter to the writer (1868).
¶ 'Trans. Geol. Society of Glasgow,' vol. ii., part 2, p. 213; ibid., p. 155.

by the Entomostraca seems to have been that of scavengers of animal matter.

Amongst the above generally minute organisms, the molluscs lived and flourished, often contributing to the building of the limestones; and amongst the most important class of mollusca in this respect were the *Brachiopoda*, placed by naturalists almost in the lowest rank of this sub-kingdom.

I shall close this branch of our subject by offering the following synopsis of the chief limestone builders of successive geologic periods in ascending order.

LAURENTIAN.	Foraminifera (?). *Eozoon.*
SILURIAN and DEVONIAN.	Corals (chiefly of the orders *Zoantharia tabulata*, and *Z. rugosa* of MM. Milne-Edwards and Haime), Crinoids, Brachiopods, and Entomostraca.
CARBONIFEROUS	Corals (*Zoantharia tabulata*, *Z. rugosa*, *Z. tabul sa*), Crinoids, Bryozoa, Brachiopods, and Entomostraca.
PERMIAN	Corals (not abundant; *Zoantharia tabulata*, *Z. rugosa*), Bryozoa, Conchifera, Entomostraca.
TRIASSIC	Bryozoa, Echinoderms, Conchifera.
JURASSIC	Corals (*Zoantharia aporosa*), Bryozoa, Echinoderms, Molluscs largely.
CRETACEOUS	Amorphozoa, Foraminifera, Corals (*Zoantharia aporosa*, *Z. tabulata*, *Z. rugosa*) Echinoidæ, Bryozoa, Entomostraca, Brachiopods (Terebratulæ).
TERTIARY	Foraminifera (Nummulites), Corals (*Zoantharia aporosa*, *Z. perforata*, *Z. tabulata*), Echinoderms (*Echinoidæ*, *Asteroidæ*), and Ophiuridæ.

We have now to turn to the discussion of those strata of mechanical origin which are associated with the limestones.

SEDIMENTARY, OR INORGANIC, STRATA.—In contrast with the calcareous rocks, not only as regards origin but in mode of distribution, we may include all those strata which are strictly mechanical, such as conglomerates, sandstones, shales, clays with their several varieties and combinations, whether metamorphic or otherwise. It is not necessary to enter into a description of the manner of formation of this class of strata, except to observe that from the more rapid subsidence of the coarser particles which are brought down into the ocean and distributed over its bed—truncated sheets of strata of this class will have a tendency to increase in thickness in the direction of the source, or sources, of sediment.

Now, the existence of sandy or muddy sediment in the waters of the sea is well known to be detrimental to the growth, and even vitality, of many of the delicate organisms which chiefly contribute to the formation of limestones. On this point the evidence of observers is conclusive as regards the present inhabitants of the sea, and we may feel sure this adverse influence of muddy sediment

extended far back through all geologic times. Taking the Polyps as the chief limestone builders of the present period, we find them flourishing in mid-ocean, or in tracts removed from the influence of turgid waters. Thus Mr. Darwin, when describing the coral reefs and atolls of the Indian and Pacific Oceans, refers to them as being at an immense distance from any continent, and where the water is perfectly limpid.* Mr. Jukes describes the water surrounding the barrier reef off the coast of Australia as being quite clear;† and Dr. T. Wright, in his summary of the character and conditions of development of modern coral reefs, says,‡ "where the bottom is muddy, and the rivers pour fresh water in any great abundance into the sea, there the reef-building Polyps are absent."

The Foraminifera, a group of limestone builders, distinct from Polyps and Echinoderms, seem to have been most prolific in limpid waters. In our present seas we find them largely associated with the Polyps, as well as engaged in forming a deposit over the bed of the mid-Atlantic, which if converted into land would yield a limestone not dissimilar to chalk.§ In geologic times we find two very important and pure limestone formations—the chalk, and nummulite limestone of the Eocene period,—for the most part composed of the shells of these little animals.

That the Brachiopods and the Crinoids especially of past times flourished with greatest vigour in limpid seas, is perfectly clear from the mode of their occurrence in the rocks themselves. Not only are they most numerous as individuals in the beds of the less earthy limestones, but we frequently notice the species (or their representatives) becoming dwarfed in size, as well as fewer in numbers, when we pass from limestones into adjacent clayey strata. In the Carboniferous limestone of Derbyshire, where these animal remains are found in such marvellous profusion, the rock itself contains scarcely a band of shale through hundreds or even thousands of feet.

If, then, there existed this detrimental influence, exerted by mud or sand held in suspension, on the vital development of those marine animals which contributed to the formation of limestones, it follows, that during any special geologic period in which both classes of strata (calcareous and sedimentary) were being formed, the maximum development of each class must have been in directions opposite to each other. If, for instance, the sediment was being transported and deposited over the sea-bed by a current coming from the north, the contemporaneously formed limestone would *grow* with greatest rapidity, and attain its greatest proportions far

* 'Naturalist's Voyage,' p. 468.

† Voyage of H.M. ship 'Fly.'

‡ 'On Coral Reefs, Past and Present,' Trans. Cotteswold Naturalists' Club, 1866.

§ See Dr. G. C. Wallich's "Account of the Deep-Sea Soundings," 'Quart. Journ. Science,' vol. i.

out to sea to the southward, and beyond the region to which the sediment was carried, and of this phenomenon we have several examples over the British area, the most striking of which are furnished by the Carboniferous, Permian, and Lower Jurassic formations.

As I have on a former occasion treated this branch of the subject at length, it will only be necessary here briefly to refer to the illustrations afforded by two of these groups of strata.*

Carboniferous Series.—The calcareous central member, or Carboniferous limestone, attains in central England a development nowhere else reached in Britain. Its base is never exposed, although the beds are over many parts of Derbyshire thrown into highly inclined positions with numerous faults and flexures. Several sections measured with the utmost care by the geological surveyors combine to give a thickness of more than 4000 feet for this great calcareous formation in this part of the country, where it is also in composition remarkably free from the intermixture of shales, sandstones, or other sedimentary materials. It is in this district also that its organic origin is strikingly brought to light, for it abounds in corals, shells, and crinoidal remains. To the region of Derbyshire we may emphatically point as a former ocean-bed, where during the era of the Carboniferous limestone, a limpid sea offered full scope for the development of the marine animals which were the limestone builders of that geologic period.

If, from the Derbyshire district, we trace the range of the Carboniferous limestone northwards into Scotland, we find this formation gradually deteriorating both in quality and thickness. In North Lancashire, Cumberland, and Yorkshire, it has nowhere a thickness exceeding 2000 feet, frequently less; and, as shown by Professor Phillips, is split up into several distinct bands by the intercalation of beds of shale and sandstone with coal. This deterioration is still more strikingly exhibited when we pass into Scotland, for in the Carboniferous districts of Lanarkshire, Renfrewshire, and the Lothians, the formation is represented by several thousand feet vertical of sandstones and shales, with coal and ironstone, and a few beds of limestone only attaining a combined thickness of about 150 feet. Here, then, we have a clear illustration of the effects produced in the calcareous strata by the introduction of muddy or sandy sediment. The same waters which, being free from impurities in the region of central England, gave scope for the maximum development of the limestone, were charged with sand or clay towards the north, and in proportion as this was the case interfered with the growth of the limestone, and in the Scottish area well nigh prevented its formation.

Carboniferous Sedimentary Strata.—But not only did the

* See my paper, "On the Relative Distribution of the Carboniferous Strata of Great Britain," 'Journ. Geol. Soc. London,' vol. xviii., p. 127 (with map).

antagonistic influence of the muddy waters pervade the Carboniferous area during the period of the central calcareous member, but it held sway and gained ground throughout the succeeding stages so as almost to annihilate the limestone builders during the periods of the millstone grit and coal-measures, or cause them to migrate into other regions of the ocean. But the point we have specially to deal with is the direction from which this sedimentary matter was drifted. Now, the very accurate measurements which the Carboniferous series enable us to obtain, point clearly to a northerly source, for in this direction the sedimentary strata tend to attain their greatest development, and this, be it observed, is the direction in which the calcareous strata tend to thin away and disappear. Thus if we take a series of vertical sections along a line from Leicestershire and Warwickshire into North Lancashire, we find the proportion of the Yoredale series, millstone grit, and coal-measures as follows:*—

Leicestershire & Warwickshire.	N. Staffordshire.	S. Lancashire.	N. Lancashire.
Feet.	*Feet.*	*Feet.*	*Feet.*
2600	9000	12,130	18,700

Here, then, we see a steady augmentation in the thickness of the sedimentary materials within a distance of about 120 miles to the extent of 16,000 feet.† In Scotland and the north of England, it is true, owing to a shallower sea bed, and the nearer approach to the parent land, the increase is not maintained, but the northern source of the sedimentary materials is no less clear.

Now, if it be inquired, "What relationship as regards the mutual development of the calcareous and sedimentary materials can there be between the period of the Carboniferous limestone and that of the succeeding strata?" the reply is this: *that these relations were maintained, though in different proportions, throughout all the stages of a natural group of strata representing a geological cycle (such as the Carboniferous), and were only reversed or considerably changed with the introduction of a new natural group.*

Permian Series.—My illustration from this group of the English strata will be stated in briefer terms than the foregoing.

The central calcareous member of this group is clearly represented by the magnesian limestone of Durham, and Yorkshire and Nottinghamshire along the north-east of England. Along this region it attains a maximum thickness of about 600 feet, as shown by Professor Sedgwick; while the overlying sedimentary strata are but feebly represented, and the lower red sandstone (*Rothe-todte-liegende*) does not exceed 250 feet in thickness. Now, if we com-

* These measurements are taken chiefly from sections of the Geological Survey of Great Britain.

† See my paper "On the Thickness of the Carboniferous Strata of Lancashire, &c.," 'Jour. Geol. Soc. London,' vol. xviii.

pare this section with that on the west of England (Cumberland and Lancashire), we find the conditions of these several members completely reversed in respect of development. Here the central calcareous member is reduced to very small dimensions, being represented in South Lancashire by marls with thin bands of limestone,* and in Cumberland by thin bands of magnesian limestone near Whitehaven, Stank, and Bispham. On the other hand, the upper and lower sedimentary beds attain great dimensions; the former, as Sir Roderick Murchison has shown, represented by the St. Bees sandstone, over 600 feet in thickness; and the latter by the Penrith sandstone, estimated by Professor Harkness to attain a thickness of 3000 feet. It is clear therefore that the sedimentary region in the north of England area has been to the westward, and the calcareous area to the eastward; and that in this group there has been a development from opposite directions of the two types of strata.†

	North-west of England.	North-east of England.
	Feet.	*Feet.*
Upper Permian (Sedimentary) ..	600	.. .. 50 to 100
Middle „ (Calcareous) ..	10 to 30	 600
Lower „ (Sedimentary) ..	3000	.. .. 100 to 250

I now pass on to the consideration of the physical conditions of which these interchanges of vertical development between the calcareous and sedimentary strata are the palpable representatives.

Natural Grouping of Strata on a Threefold System.—Regarding the calcareous strata as the representative of the pelagic, or deep-sea, conditions, and the sedimentary as the representative of more littoral conditions, it is to be understood that each of the three divisions of a natural group represents the *predominance* of these conditions at each successive stage, and not their existence to the exclusion of others. *We must also take as representatives of a special group that section of it which is somewhat intermediate between its extreme conditions of littoral and pelagic;* for we can easily understand that there must have been tracts in the ocean where sediment was never deposited during (for instance) the whole of the Carboniferous period, and where the only representative of the series would be the Carboniferous limestone. And, on the other hand, there must have been tracts bordering on the old land surfaces of the period where the calcareous member was scarcely represented (as in Scotland), and where sedimentary strata were formed, almost to the exclusion of others. As a matter of fact, however, it is this portion of the geological groups (between

* As shown by Mr. E. W. Binney, Mem. Lit. and Phil. Soc, Manchester, vol. xii., &c.

† I have not referred to the Lower Permian beds of the central counties, as the relationship of these beds to those of the north is somewhat obscure. They were probably deposited in separate basins.

the littoral and the pelagic) which is generally preserved for our observation, as it is only on rare occasions that we meet with the actual margins of geological formations.

But not only does a natural group represent special regions of the sea-bed, but also, we may suppose, three historical periods of formation, making up in the aggregate a geological cycle; the first of movement, the second of quiescence, and the third of movement again, terminating in those great oscillations, accompanied by denudation, which brought the cycle to a close, and produced discordant stratification. We have already seen that the formation of calcareous matter depends mainly on the absence of muddy or sandy sediment in the waters of the sea. This state of things would naturally attain predominance after the close of a series of vertical movements, accompanied by a maximum of subsidence of the land. The prevalence of sediment would be brought about during periods of disturbance, accompanied by a maximum of elevation of the land. Thus the three stages of a natural cycle going to form a geological group may be thus expressed:—

Natural Group.
- Lower stage, *representing* prevalence of land with movement, *producing* chiefly sedimentary strata.
- Middle stage, *representing* prevalence of sea with quiescence, *producing* chiefly calcareous strata.
- Upper stage, *representing* prevalence of land with movement, *producing* chiefly sedimentary strata.

On the principles here stated it is easy to account for several phenomena of frequent occurrence amongst the formations of our globe. We can account for these interstratifications of calcareous and sedimentary strata, called "passage-beds," of which we have good examples, for instance, at the base of the Yoredale series of England, by supposing the alternate predominance of muddy and clear water in the sea at the margin of the pelagic and littoral regions. We can also account for the fact that a natural group of strata is rarely if ever introduced by a series of limestones, but generally by coarse sedimentary strata, often conglomerates. I question if a true natural group is ever represented by limestones in its lowest beds, and if this should happen to be the case it may be concluded that it is exceptional and due to the local absence of a lower member. A natural group is also seldom terminated by a calcareous stratum, and when this is the case (as, for instance, the chalk of England) it is owing to the local absence of an upper sedimentary member. I am not, however, prepared to say that this is invariably the case, as the Upper Silurian group of the United States seems to offer an illustration in an opposite direction.*

* It is questionable, however, whether this is really an exception, as the Oriskany sandstone might be assumed without much hesitation to be the upper sedimentary member of the Silurian; and the "Cauda galli grit" the lower member of the Devonian series.—See 'Siluria,' 4th edit., pp. 436–7.

British Formations arranged under the Ternary Classification.

Applying the above principles to the classification of the British stratagraphical series, I shall give a short statement regarding each group as arranged in the accompanying table, in ascending order (see Plate), reserving to a future occasion the consideration of foreign groups.

Laurentian Group (Sir W. Logan).—The existence of this earliest known group of rocks in the British Isles was first announced to the scientific world by Sir Roderick Murchison in 1856, and again in 1859. It occupies the north-west coast of Scotland, from Cape Wrath southward to Loch Enard as well as the whole of the Hebrides. It consists mainly of highly metamorphosed gneiss, with only thin bands of limestone at rare intervals. The prevalent strike is from N.W. to S.E., and it is overlaid discordantly by Cambrian rocks, with a prevalent strike from N.E. to S.W.*

The formation as represented in Britain is manifestly incomplete, the calcareous beds with *eozoon canadense*, which are finely developed in Canada, being absent, and as Sir Roderick Murchison considers the British rock to be the representative of only the lower division of the Laurentian series as it occurs in Canada, there is a loss of one entire member. It is therefore impossible to represent this fundamental rock in our Geological series otherwise than as a mere fragment of a great formation.†

The Cambrian Group.—This group as it occurs in Britain, especially in the Longmynd, where as shown by Sir R. Murchison it lies at the base of all the Silurian series, has no calcareous representative. In the north-west of Scotland, the basement beds, consisting of hard chocolate-coloured sandstone and conglomerate ‡ rising into the lofty mountain of Queenaig, are truly represented. These are surmounted by quartzites with crystalline limestones of Lower Silurian age. In Wales, on the other hand, the base is not visible; so that we find what seem to be the upper beds surmounted by the "Lingula Flags" of the "Primordial Zone." As this great formation is devoid of a calcareous representative in Britain, it cannot be regarded otherwise than as a fragmentary.

The Lower Silurian Series.—The "Lingula Flags" of Britain, being entirely composed of sedimentary strata, and exhibiting no very marked discordance in the stratification with reference to the Llandeilo series, form naturally a portion of the lowest member of

* See new geological map of Scotland, by Sir R. Murchison and Mr. A. Geikie, 1862.

† 'Siluria,' 4th edition, pp. 10–12. ‡ Ibid., p. 15.

the Lower Silurian series, of which the Bala and Llandeilo limestone series form the Middle, and the Lower Llandovery rocks and Caradoc sandstone, the upper sedimentary series.

In Bohemia, however, as M. Barrande has shown, this group, named by him "Zone primordiale," assumes a threefold arrangement, with a central calcareous member, as represented in the column of strata.

Middle Silurian.—A Middle Silurian group is not yet generally recognized, but, as Professor Ramsay has very clearly shown,* there is a great physical break between the Lower and Upper Llandovery beds, accompanied by the disappearance of the great majority of species of animals belonging to the Caradoc beds, while at the close of the Upper Llandovery series (Tarannon shale) there is a second break and unconformity. There are therefore apparently very good grounds for a Middle Silurian group, of which the Upper Llandovery limestone may be considered the central calcareous member.

Upper Silurian Series.—The basement beds consisting of the Derbyshire grits, flags, and slates, rest unconformably on the Middle Silurian series. This is the lower sedimentary member. The middle calcareous member is represented by the Wenlock and Aymestry limestone series. These two beds of limestone assume in this country an individuality and distinctive palæontological character, which, as Sir Roderick Murchison has shown, is not maintained by their Continental equivalents.† The Upper Ludlow rock and tilestones combine to form the upper sedimentary member of the group.

Devonian Series.—This natural group appears under several distinctive characters in different parts of the British Islands. Nowhere, indeed, is the series represented unbroken and complete; but in Devonshire we have probably the nearest approach to this. I shall therefore, in dealing with this great formation, call to my aid those "*breaks in succession*" which Professor Ramsay has recently dealt with in his Presidential address to the Geological Society of London.‡

Devonshire.—The ternary division of the series into a lower and upper sedimentary, with a middle calcareous member, seems to have been very clearly established, both by the original observations of MM. Murchison and Sedgwick, and confirmed by the recent detailed examination of Mr. Ethridge.§ The classification here proposed differs slightly from that of these authors who have established a Lower, Middle, and Upper Devonian series; but as I

* Presidential Address to the Geological Society of London, 1863.

† This view is borne out by M. Barrande, who refers the three upper limestones of the Silurian series in Bohemia to the Wenlock and Ludlow beds conjointly, finding it impracticable to make the distinction of these beds into two groups corresponding to the English series.

‡ 1863–4.

§ 'Quart. Journ. Geol. Soc.,' vol. xxiii., p. 580.

find it necessary to confine the middle division to the Ilfracombe limestone series alone, the passage from the sedimentary conditions of the lower into the calcareous conditions of the middle, and from these latter into the sedimentary conditions of the upper series appears in this district to have been gradual and uninterrupted.

Herefordshire.—The Old Red Sandstone in this district and South Wales appears, from the observations of Sir Henry De la Beche, to consist of two members lying discordantly on each other, the upper member appearing to pass upwards into the Carboniferous series, the lower to graduate downwards into the Silurian. A possible explanation which I venture to offer is, that we have here the representatives of the upper and lower sedimentary members of the ternary group, of which the central calcareous member has not been deposited in this region. In illustration of this view I may point to the Trias of England, which, as we shall presently see, affords a similar example capable of ready explanation.

Scotland.—In Scotland we seem to have a succession of beds somewhat parallel to that of South Wales. Mr. A. Geikie has divided the Devonian series into three groups, each resting unconformably on that below it. But as the upper member of this threefold series is stated by him to graduate upwards in the lowest beds of the Carboniferous rocks, I have ventured in this classification to place this "Upper Old Red Sandstone" at the base of the Carboniferous series, with which it seems to be more closely allied than with the "Middle Old Red Sandstone." We have then two sedimentary members resting discordantly on each other, and leaving an intermediate gap in the succession, which the middle member ought properly to have filled, as in the case of South Wales.

Ireland.—The investigations of Mr. Jukes seem to have brought to light in Ireland, as in Scotland, a double series of sedimentary strata resting discordantly on each other.

To the unrepresented space between these members may, I think, be referred the position of the central calcareous member, and the two divisions to the upper and lower sedimentary members of a natural group. Thus we have the "Dingle and Glengariff Grits" of the lower stage surmounted discordantly by the Coomhola Grits of the upper. If the above explanation of a highly difficult problem regarding the relations of the Devonian series in Wales, Scotland, and Ireland has any approach to the truth, the entire absence of the middle calcareous member may probably be accounted for by supposing that during this stage in the geological cycle these tracts had been elevated into land surfaces, while in the Rhenish and Devonian regions the limestones of the middle Devonian group were in course of formation. Such oscillations of the sea-bed would serve also to account for the break and unconformity between the upper and lower members of the group.

Carboniferous Series.—The threefold division of this group with its calcareous central member in Great Britain has already been so fully alluded to, that it is scarcely necessary for me to add to what I have already written. I may, however, here remark that although there is a nearly continuous and uninterrupted sequence in the beds from the lower limestone shale throughout, there are both in England and Scotland occasional slight breaks, denudations, and unconformities, but that these are of an exceptional character, and of limited extent. I have already mentioned my reason for placing the upper "Old Red Sandstone" of Scotland at the base of the Carboniferous series of that country.

Permian Series.—It is almost superfluous to insist upon the threefold classification in the case of this group, as originally established by Sir Roderick Murchison and Professor Sedgwick, in the north-east of England, and more recently developed in Lancashire and Cumberland by the labours of Professor Harkness, Mr. Binney, and others. Having already described the relations of these beds (see page 361), I shall only here refer to what I consider to be the true position of the Lower Permian rocks of central England and Shropshire with reference to those of the north of England. Those who are familiar with the aspect and physical characters of the Permian beds in these two districts cannot fail to have observed that they belong to two different and distinct types. And regarding as I do the beds of central England and Shropshire as belonging exclusively to the Lower Permian series, the most probable explanation of the difference in their mineralogical characters, as compared with their representatives in the north of England, appears to be that each group was deposited in a separate hydrographical basin, disconnected by a barrier of lower Carboniferous rocks which crossed from west to east under the central plain of Cheshire and parts of South Derbyshire. Into the evidence of the former existence of this barrier I have fully entered in a paper read before the Geological Society of London in 1869.

Triassic Series.—It is scarcely necessary to observe that in Britain we have no representative of the central calcareous member of this natural group. The reasons for the absence of the Muschel-kalk and St. Cassian limestones, which on the Continent form the central calcareous member of the group, is now clearly understood. In England the basement-beds of the Keuper division rest, with a slight discordance, upon an eroded surface of the Bunter, representing a gap in geological time during which the English area was elevated into dry land, and only submerged again at the commencement of the Keuper period. I regard this case of the Trias of England, bereft of its middle calcareous member, as a parallel case to that of the Devonian group of Wales, Scotland, and

Ireland, and as throwing light upon the mutual relations of the upper and lower members of that group.

Jurassic Series.—I venture to assert that no very valid objection can be taken to the arrangement of the three Jurassic groups here adopted, and which are given in the table of geological formations. If we examine the elaborate tables of the distribution of species which Professor Ramsay has, with the aid of Mr. Etheridge, laid before the Geological Society, we shall observe that there are species common to the groups as here arranged, and that the theory of "migration" accounts for the temporary change of groups of animal remains. (See Plate.)

The Liassic series seems to admit of a sub-group if we take the marlstone (or Middle Lias) as the central calcareous member. This, however, is a distinction to which it is scarcely entitled. The upper sedimentary member of the Upper Jurassic group is only very partially represented by certain littoral and marine beds of the Middle Purbecks. Their marine equivalents, and certain antecedent strata now lost, are, however, the true representatives of this stage. That these have been denuded away from off the upper surface of the Portland limestone is, I think, made sufficiently clear by the eroded surface which this rock generally presents. On the Continent the same phenomena are presented, pointing to the absence of certain strata through denudation. On this point M. D'Orbigny says:—"Quant aux limites supérieures rien nous manque pour la séparation nette et précise qui existe avec l'étage néocomien. Cette séparation, en effet, se montre sous tous les formes, par discordances et par des discordances de dénudations et d'érosions." *

Cretaceous Series.—The close of the Upper Jurassic period is marked by a complete physical break, and, as above stated by D'Orbigny, by denudations of the Jurassic beds. This is observable all along the line of the chalk Downs through Wiltshire and Oxfordshire, where we find occasionally (as Dr. Fitton long since pointed out) the Greensand resting on different members of the Jurassic series, from the Portland Oolite down to the Coral Rag inclusive. As regards the accompanying change in the palæontological features, Professor Ramsay remarks:—"The break in the succession of *species* is as great as in any part of the Palæozoic series, and is shown by the total change of species which marks the introduction of the marine cretaceous formations." †

The Lower Greensand, Gault, and Upper Greensand, though showing in places evidence of breaks in the succession,‡ form on the whole a well-defined lower sedimentary member of the Cretaceous

* 'Paléontologie,' p. 563.

† Anniversary Address to the Geological Society of London, 1864.

‡ This break is shown to be large in the case of the Lower Greensand, for out of 28 species 233 are peculiar and 51 (or 18 per cent.) pass upwards.—Ramsay, *ibid.*

group. The Upper Greensand may be considered as "a passage-bed" from the sedimentary to the great calcareous central member, the Chalk, a view which seems borne out by the palæontological relations of the beds, for of the known species 20 per cent. pass up into the overlying beds.* The upper sedimentary member is lost to us, both in Britain and on the Continent, through denudation, for we find the basement beds of the Tertiary series resting everywhere on an eroded surface of the Upper Chalk, or of the Maestricht beds. On this point D'Orbigny remarks:—"Pour les limites stratigraphiques supérieures (de l'étage Danien) elles sont marquées par des discordances de dénudation et d'isolement les plus prononcées;" and as regards the enormous break in time represented by the palæontological changes Professor Ramsay remarks:—"Of the 521 species known in our Upper Chalk, all, with the exception of *Terebratula caput-serpentis,* and a few Foraminifera, have apparently become extinct during that vast period that elapsed between the close of the Cretaceous and the beginning of the Eocene period in England." It is clear, then, that the series is incomplete;—there is a missing member.

Tertiary Series.—The Woolwich and Reading series of Mr. Prestwich together with the London clay, form in England the natural lower sedimentary series of the Tertiary group. These were deposited in a sea open to the north and west, and at the close of this stage a general depression of the middle and south of Europe took place, accompanied by the introduction of the "Middle Eocene series" of Sir Charles Lyell. In the great nummulite limestone formation we cannot but recognize the middle calcareous member of our ternary classification, which has spread over large tracts of Europe, Asia, and Northern Africa, but is absent in Britain. Sir C. Lyell and Viscount d'Archiac have shown that these beds are represented in Belgium and French Flanders by strata characterized by three species of nummulites, which are also more abundantly developed in the limestone formation of the Alps, where it attains a magnitude and characteristically calcareous features unknown in Northern Europe. I regard this as another illustration of development from *opposite directions* of the calcareous and sedimentary members of the same natural group.

The upper sedimentary stage is represented by the black shales, marls, and sandstones of Glarus ("flysch"), and other strata of the Miocene period, of which the "molasse," a great conglomerate or breccia of Switzerland, is the best representative. In England it is doubtful if we have true representatives of this stage, which completes the range of our natural groups and brings us to the confines of the Glacial epoch.

* See Table v., Professor Ramsay's Address.

IV. THE TRANSIT OF VENUS IN 1874.

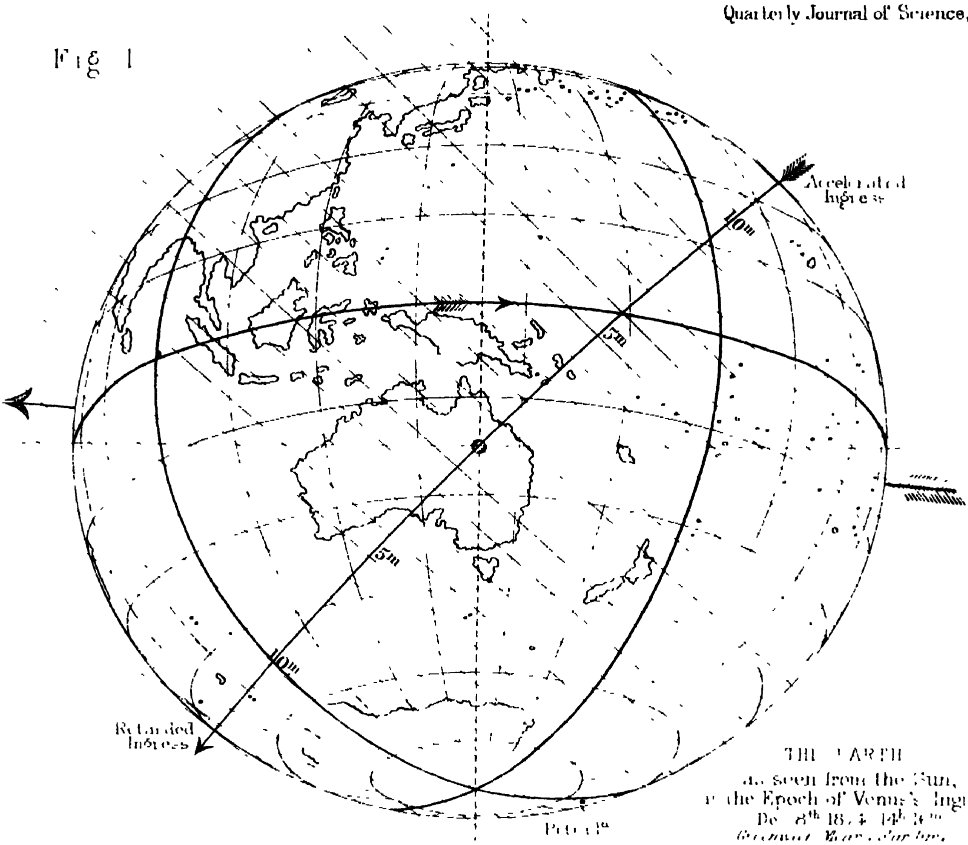
By Rich. A. Proctor, B.A., F.R.A.S.

On account of the important bearing of the transits of Venus upon the problem of the sun's distance, men of science are looking anxiously forward to the two transits which occur in the present century. Although the later of the two will not take place for thirteen years, its circumstances have already been examined. Indeed both transits were subjected to careful examination by the Astronomer Royal so far back as 1857; and since then he has continued to put forward from time to time the considerations which have suggested themselves to him as his examination of the subject proceeded. Early in the inquiry he expressed the opinion that the method founded on the observed differences of the transit's duration, as seen from opposite points of the earth's surface—which method had been the sole one employed in the treatment of the transit of 1769—is wholly inapplicable to the transit of 1874; and he suggested another method of utilizing that transit,—a method less perfect in itself, more difficult (astronomically) to carry out, and involving processes of preparation essentially different from those which would be required under the other method. To the preparations thus called for, astronomers and geographers have hitherto, I believe, solely confined themselves.

Having had occasion to examine the reasoning of the Astronomer Royal, and to test the conclusions he had arrived at, I have been led to form a somewhat different opinion of the value of the transit of 1874, so far as the simpler method of observation is concerned. I have found that, if consideration be made of internal contacts—the only phenomena on which estimates of the sun's distance have ever been founded—the actual difference of duration which can be made available in 1874, is about 35m. or 36m., as against an outside value of 28m. in 1882, and an actual observed maximum of difference of 23½m. in 1769.

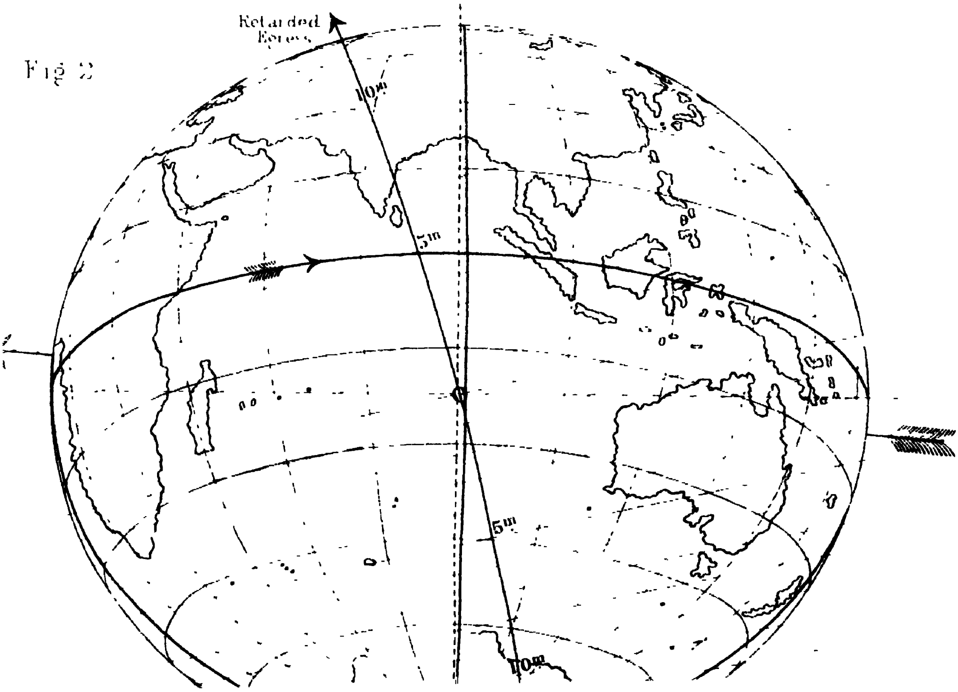
I am sensible that mere magnitude of observed difference is not the sole point on which the value of a transit depends. The rate at which the planet crosses the sun's limb is an almost equally important subject of consideration. I shall be able to show that when this point is dealt with in the manner most unfavourable to my case, the value of the transit of 1874 yet remains superior to that of the famous transit of 1769 (as actually utilized), and scarcely inferior to the most favourable estimate which can be formed of the transit of 1882. Therefore, remembering the importance which has been always attached to the observations made in 1769, and the immense advances since made in the construction of instruments

Fig 1



THE EARTH
as seen from the Sun,
at the Epoch of Venus's Ingress
Dec 8th 1874 14h 36m
Greenwich Mean Time.

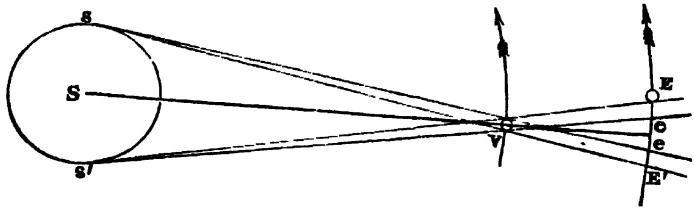
Fig 2



and in observing-skill, we cannot look upon the transit of 1874 as otherwise than highly valuable.

If we briefly consider the general nature of a transit, we shall be the better able to define the circumstances on which the value of any particular transit depends.

Fig. 1.



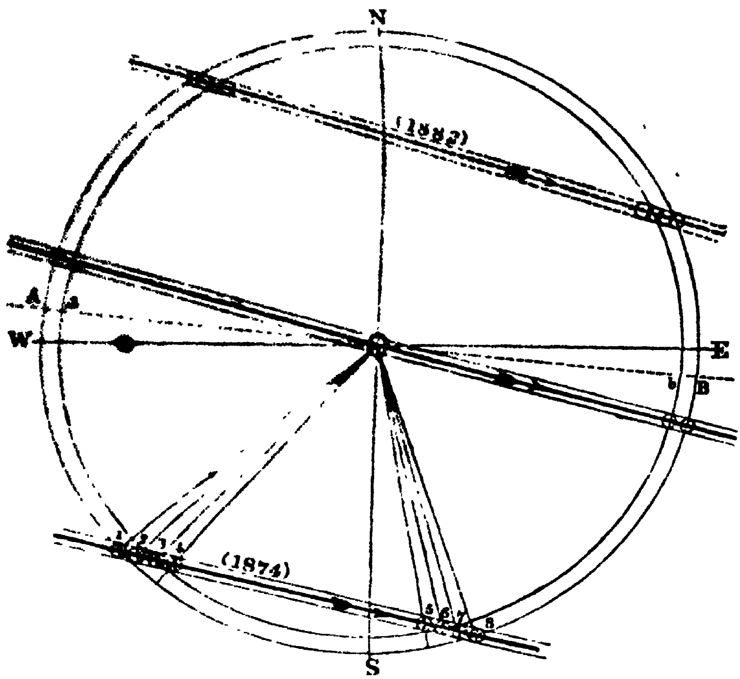
In Fig. 1, let s represent the sun, v Venus, and E the earth, the plane of the paper representing the plane of the ecliptic, so that the path of Venus (supposed to be near one of her nodes) must be conceived as inclined rather more than 3° to the plane of the paper. The arrows show the direction in which the planets move.

Conceive the sun and Venus enveloped by two double cones *s* e′ e *s*′ and *s* E′ E *s*′, one having its vertex inside, the other having its vertex outside, the orbit of Venus. These cones have a common axis, namely, the line joining the centres of Venus and the sun. Now it is clear that as Venus with her more rapid motion sweeps round the sun, the accompanying cones must overtake the earth (situated as shown in the figure), and that as they sweep onward, the earth will pass through them. As this takes place, there will occur the following eight phenomena in the given order: The forward part of the outer cone will reach (i) the nearer, then (ii) the farther side of the earth's globe; the corresponding part of the inner cone will reach (iii) the nearer, then (iv) the farther side of the earth's globe; next, the backward part of the inner cone will reach (v) the nearer, and (vi) the farther side of the earth; and lastly, the corresponding part of the outer cone will reach (vii) the nearer, and (viii) the farther part of the earth. And these several events will readily be seen to correspond to the occurrence of:—

(i)	Most accelerated	external contact	at ingress.
(ii)	„ retarded	„	„
(iii)	Most accelerated	internal contact	„
(iv)	„ retarded	„	„
(v)	Most accelerated	„	at egress.
(vi)	„ retarded	„	„
(vii)	Most accelerated	external contact	„
(viii)	„ retarded	„	„

In Fig. 2 the actual nature of the earth's passage through the cones is illustrated, as exactly as possible, to scale. In this figure

FIG. 2.



the circles A 1 8 B and a 2 7 b represent the sections of the outer and inner cones where they cross the earth's orbit. For convenience we consider these circles to be at rest, and examine only the effects of the earth's relative motion. B O A is parallel to the ecliptic. As the earth is in reality moving from right to left in a direction parallel to B O A, and with a less rapid motion than that of the two circles A B, a b, it is clear that the earth's relative motion is from left to right. Also, as the circles are crossing A O B from south towards north (for Venus is at an ascending node both in 1874 and 1882) it is clear that the earth has a relative motion from north to south. The triple sets of lines marked with arrows show the actual direction of the earth's relative motion (the small circles representing the earth in various parts of her passage). Calculation shows that this relative motion is such that a central transit would occupy nearly eight hours. The triple lines are inclined to A O B at about $9\frac{1}{2}$ degrees; and 14 degrees to the east and west line E W.

The actual path of the earth across the circles in 1874 and 1882 is indicated by the lower and upper sets of triple lines, respectively.

In considering the circumstances of the transit of 1874, I dismiss all consideration of the phenomena marked (i), (ii), (vii),

and (viii) in the above table. But besides the four remaining phenomena I take into account the passage of the earth's *centre* across the circles, because Mr. Hind's elements are calculated only for these phenomena, and without considering them I should have been unable to test the accuracy of my own conclusions by comparing them with his results.

Thus the eight phenomena corresponding to the positions of the earth, numbered 1 to 8 in Fig. 2, correspond to—

(1) External contact for the earth's centre at ingress.
(2) Internal contact most accelerated at ingress.
(3) „ as seen from the earth's centre.
(4) „ most retarded.

and the four corresponding phenomena at egress.

The treatment applied to these phenomena has been the following:—Taking Mr. Hind's epochs for the external contacts at ingress and egress, I have thence calculated all the remaining epochs and the position-angles (NO1, NO2, &c., Fig. 2); the exact agreement of my estimates of such of these elements as Mr. Hind has calculated with the results he has obtained has sufficed to establish the correctness of the mode of operation. Thus has been formed the following table, in which the numbers 1, 2, 3, &c., refer to the figures in Fig 2:—

		Epoch.					Position-angle.	
1,	Dec. 8,	13h.	46m.	56s.	.. ..	NO1 =	130°	33′
2,	„	14	3	59	.. ..	NO2 =	133	56
3,	„	14	15	57	.. ..	NO3 =	136	28
4,	„	14	29	5	.. ..	NO4 =	139	26
5,	„	17	43	58	.. ..	NO5 =	168	58
6,	„	17	57	5	.. ..	NO6 =	166	0
7,	„	18	9	4	.. ..	NO7 =	163	28
8,	„	18	26	5	.. ..	NO8 =	160	5

The results thus obtained have been applied to the formation of Figs. 1 and 2 (Plate), in the following manner:—

Rejecting phenomena 1 and 8 as no longer concerning us, the triple sets of phenomena 2, 3, 4, and 5, 6, 7 (see Fig. 2), are alone considered. Properly speaking, we should form an orthographic projection of the earth as supposed to be seen from the sun at each of the six epochs corresponding to these phenomena. But no error of importance will be introduced if we take the epochs of the two central passages, 3 and 6. All that will be necessary is to remember that in considering accelerated or retarded ingress, the earth in Fig. 1 (Plate) must be supposed rotated backwards or forwards respectively, through the arc due to about 12 minutes' or 13 minutes' rotation respectively, while corresponding charges must be supposed applied to the earth, as seen in Fig. 2 (Plate), at the

corresponding epochs at egress. It must be remarked further that Figs. 1 and 2 (Plate) will be found not to correspond to the hours of Greenwich mean solar time, which are affixed to them, but to the corresponding hours of apparent solar time.* It is clear that the conditions of a transit have nothing to do with our horological arrangements, but only with the actual aspect of the earth as supposed to be seen from the sun.

Fig. 1 (Plate), then, represents the earth as she would appear from the sun when in the positions marked 2, 3, or 4, in Fig. 2 (Woodcut), or in any intermediate position. In a similar way Fig. 2 (Plate) represents the earth as she would appear when in the positions 5, 6, or 7, or in any intermediate position.

The lines which lie side by side across the earth's face in Fig. 1 (Plate) represent the actual position of the edge of the large circle (a b of Fig. 2), at intervals of one minute, counted with reference to the moment of central passage. We notice that while the large circle takes but about 12 m. in sweeping across the north-eastern hemisphere, it occupies more than 13 m. in sweeping across the south-western. This obviously agrees with the facts exhibited in Fig. 2; since it is clear that the nearer the earth approaches towards the middle of the line marked 1874, the slower is her rate of approach towards O.

Considerations of precisely the same sort apply to Fig. 2 (Plate), which will be at once understood when examined with reference to the three positions of the earth marked 5, 6, and 7, in Fig. 2 (Woodcut).

It must be here remarked that as respects all this part of the inquiry there is no doubt or difficulty whatever, the calculations involved being of the most elementary character. But we may stay a moment to inquire how far the results exhibited in Figs. 1 and 2 (Plate) agree with those which have been obtained by the Astronomer Royal; because, although there is no difficulty in the work thus far, a different method has been pursued by him in obtaining corresponding information. In obtaining those points of the earth marked "accelerated ingress," "retarded ingress," "accelerated egress," and "retarded egress" in Figs. 1 and 2 (Plate), the Astronomer Royal has employed the terrestrial globe adjusted with reference to the epochs of the passage of Venus' centre across the centre of the sun, the phenomena being supposed to be seen from the earth's centre. This would correspond to the passage of the centre of the small circles, marked 1, 2, 3, &c., in Fig. 2 (Woodcut), across a large circle midway between the circles A B and a b. He has assumed the position-angles at ingress and egress to be equal to NO1 and NO8. Neither the method nor the assumptions are strictly exact (as Mr. Airy has himself pointed out),

* The equation of time on December 8th is nearly 8 m. additive to mean time.

and no correction has been made for the equation of time. It seems to me questionable whether the results are quite near enough for practical purposes. They lie severally about 315, 920, 760, and 230 miles from the positions I have obtained for the corresponding points. These corrections seem to me to appreciably affect the question at issue. The following rough description of the situation of the four spots referred to applies, however, almost as well to the Astronomer Royal's results as to mine :—

Most accelerated ingress takes place at a spot far to the north of Owhyhee; most retarded ingress in a place far to the west of Kerguelen's Land and Crozet Island. Most accelerated egress takes place near the Antarctic continent in longitude far to the east of Victoria Land; most retarded egress takes place in the north-east of European Russia.

The actual longitudes and latitudes of these places I have calculated to be, in order :—

	Latitude.		Longitude.
(1)	39° 45′ N.	.. ..	143° 23′ W.
(2)	44 27 S.	.. ..	26 27 E.
(3)	64 47 S.	.. ..	114 37 W.
(4)	62 5 N.	.. ..	48 22 E.

We come now to considerations which require to be closely attended to, as they involve the gist of the whole matter.

If stations (1) and (4) were identical, it is clear that an observer there, seeing most accelerated ingress and most retarded egress, would observe the absolute maximum duration of transit. So if the stations (2) and (3) were identical, an observer there would see most retarded ingress and most accelerated egress, and so observe the absolute minimum duration of transit. Or even if observers at stations (1) and (4) could be brought into communication by means of the telegraph,* as also those at (2) and (3), it would be possible to render available the total difference of twice 25 m. 6 s., which actually marks the durations of transit in 1874 considered with reference to the whole earth. This difference of 50 m. 12 s. would exceed more than twofold the observed difference in 1769.

But under the actual circumstances what has to be done is to secure a station as near as possible to both the stations (1) and (4), and so situated that the sun shall be fairly raised above the horizon at the epoch of the internal contacts both at ingress and egress; and the like for stations (2) and (3). The examination of Figs. 1 and 2 (Plate) will show that there is a difficulty in fulfilling each set of conditions. The point marked "accelerated ingress" is far

* Nothing but the consideration of expense renders this impossible or even difficult.

away on the darkened hemisphere at the moment of "retarded egress," and *vice versâ*. The point marked retarded ingress in Fig. 1 (Plate) has moved far upwards towards the centre of the illuminated hemisphere at the epoch represented in Fig. 2 (Plate), that is, far away from the point marked "accelerated egress."

It was the consideration of these circumstances which led the Astronomer Royal to pronounce the transit of 1874 altogether unfit for the purpose of observing the durations of transit, as seen from opposite parts of the earth's surface. And he suggested that four sets of observers should be sent to watch each of the four phenomena,—accelerated and retarded ingress and egress; and that by determining the exact longitudes of their stations, and so (with the aid of exact chronometers) learning the exact Greenwich time of each phenomenon, the transit might be rendered available through the comparison of the results *inter se*. Clearly the elements of difficulty and the probability of error are seriously increased in this method as compared with one which practically requires but the simple estimate of duration, and scarcely admits of being affected by chronometer errors. However, let us note that by this method an observed difference of at the outside 24 m. might be obtained;—not more, because the sun cannot be observed when too close to the horizon, and because also of the difficulty of finding suitable stations.

Now let us see what can be done towards the utilization of the transit of 1874 by the simpler method:—

Suppose the northernmost station taken in latitude 60°, that is, along the uppermost parallel in the figure. As the whole duration of transit is but about four hours, and day lasts about six hours in this latitude on December 8, we may take a place two hours on the left of the central meridian in Fig. 1 (Plate), knowing that the same place will be (at the end of transit) two hours to the right of the central meridian in Fig. 2 (Plate); and at one epoch the sun will be one hour risen, on the other one hour from setting. Doing this we find that the station (which lies in Siberia, not far from Lake Baikal) falls in Fig. 1 (Plate) on the sixth cross-line from the centre, and in Fig. 2 (Plate) above the tenth cross-line. In other words, the transit as seen from this spot exceeds the mean by $(6 + 10\frac{1}{4})$, or $16\frac{1}{4}$ minutes.

Next for the southern station. Here we have a wide choice. If we put our observer on Petra Island (a place probably very little suited for astronomical observations) we get (from Fig. 1, Plate) ingress retarded by 8 m., and (from Fig. 2, Plate) egress accelerated by 12 m., or in all the duration of transit falls short of the mean by 20 m. If we take the place marked out by the Astronomer Royal for observing the transit of 1882, a place near Repulse Bay, in east longitude 105°, we get ingress retarded by 9 m. and egress

accelerated by $9\frac{1}{2}$ m., or in all transit shortened by $18\frac{1}{2}$ m. If we take Victoria Land, in south latitude 70° (say), and east longitude 172°, we get ingress retarded by 6 m. and egress accelerated by $11\frac{1}{2}$ m., or in all transit shortened by $17\frac{1}{2}$ m. If we take Enderby Land, in east longitude 50°, we get ingress retarded by $11\frac{3}{4}$ m. and egress accelerated by $8\frac{1}{2}$ m., or in all transit shortened by $20\frac{1}{4}$ m. These four southern stations, combined with the northern station before considered, give a total difference of duration of $36\frac{1}{4}$ m., $31\frac{1}{4}$ m., $33\frac{1}{4}$ m., and $36\frac{1}{2}$ m. respectively. Also, as it would not be well to trust to a single northern station, it may be noticed that any part of the nearly circular region extending from Lake Baikal to Saghalien, and from north latitude 40° to north latitude 60°, might be used for observing the increased duration without important disadvantage as compared with the station already considered. Also, Crozet Island, Kerguelen's Land, and other parts of the Antarctic continent besides those considered, give abbreviated transits of considerable value. Thus for Crozet Island the abbreviation is no less than 17 m.; for Kerguelen's Land, 16 m. Even Macquarie Island, Royal Company Island, Hobart Town, and parts of New Zealand, might serve as useful subsidiary stations.

And now to compare the value of the transit of 1874 with that of 1882. We see that by the method of durations we get a difference of more than 36 m., whereas the maximum difference is $50\frac{1}{5}$ m. The Astronomer Royal has shown that for the transit of 1882 it is possible to take positions for observation (not by any means more favourable than those above considered) which give at the outside a difference of duration bearing to the maximum the proportion of 341 to 400. The maximum difference in the case of the transit of 1882 is only 32 m. 48 s., in place of 50 m. 12 s. as in 1874. Reducing 32 m. 48 s. in the proportion of 341 to 400, we obtain the period 27 m. 57 s. in place of the difference of $36\frac{1}{2}$ m. which the most favourable situations in 1874 will give.

If we assume that the value of a transit is not to be estimated according to the magnitude of the observable difference, because the rate with which the planet crosses the sun's limb is diminished in exactly the same proportion, and the error of observation correspondingly increased, we have the relative values of the transits of 1874 and 1882 as

$$\frac{36\frac{1}{4}}{50\frac{1}{5}} \text{ to } \frac{28}{32\frac{4}{5}}$$

or almost exactly as 6 to 7. But this extreme result, although as it stands it is altogether opposed to the theory of the utter valuelessness of the transit of 1874, is obtained on an assumption which is unsupported by evidence. Mr. Stone has shown that the formation and breaking of the black ligament connecting Venus with the

sun at the true moment of internal contact is an instantaneous phenomenon in favourable weather. In unfavourable weather the error in the observation of this phenomenon should depend rather on atmospheric causes—the length of the periods of atmospheric disturbance, and so on—than on the rate of the planet's separation from the sun's limb. If this is so, the transit of 1874 is superior to that of 1882 in the proportion of $36\frac{1}{2}$ to 28, or more than 9 to 7. If the truth lies between these extremes, the transit of 1874 may be fairly taken to have a value bearing to that of 1882 a proportion midway between 6 : 7 and 9 : 7; that is, the proportion of 15 : 14.

In any case no doubt can remain that the transit of 1874 is highly valuable, when dealt with in reference to the mode of observation we have been considering; and it seems clear that when all the difficulties and all the sources of error involved in the second method are duly considered, the simple method, founded on observed differences of duration, is to be held altogether more likely to give satisfactory results. I believe, therefore, that such preparations as geographers are already thinking of with reference to the choice of suitable southern stations for observing the transit of 1882 ought at once to be undertaken in connection with the transit of 1874.*

V. ON THE TEACHING OF NATURAL SCIENCE IN SCHOOLS.

By Edwin Lankester, M.D., F.R.S.

Although amongst educated men there is a generally accepted opinion that the teaching of one or more branches of natural science ought to be introduced into schools, there is still much indifference on the subject in the public mind, and no definite view of the

* Since the above was written the subject of the coming transits has been considered by Mr. Stone, than whom no one is better qualified to pronounce authoritatively on the principles which should guide us in utilizing those phenomena. He is of opinion that observations made when the sun has a less elevation than 10° would be altogether useless. This principle enables me to considerably augment my estimate of the relative superiority of the transit of 1874, with reference to the simpler mode of observation. In fact, the only southern stations which had seemed suitable in 1882 must at once be rejected; and thus we may say of that transit what had been said of the other, that the simpler mode "fails totally" with respect to it. On the other hand, the value of the transit of 1874 is scarcely at all affected by the application of the principle.

Mr. Stone considers the superiority which I have ascribed to the simpler method to have a real existence, but to be so slight (the values of the two modes being as 6 to 5) as to be unimportant. This is just; but the distinction between this view and the imagined total failure of the method seems not the less to require attention.

nature and extent to be given to such teaching anywhere. Anyone looking at the character of the human mind, and the accumulated knowledge resulting from its activity, must feel that the attempt to educate the human being without supplying some knowledge of the great facts of natural science is a one-sided proceeding. It is clear that, without a definite knowledge of facts, the art of being able to *talk* and *write* about them, or to *number* them, is of comparatively little importance. So obviously is this the case, that at first sight it is a matter of wonder that the teaching of the facts of natural science has not been more largely introduced into schools. The difficulty of introducing natural science into schools is of two kinds. In the first place, our school system has grown up from a period when there was little or no natural science to teach: commencing at a time when all knowledge was locked up in the languages of Greece and Rome, and precise science was confined to mathematics, those branches of culture have been universally introduced into all our high schools. Under these circumstances, the teaching of the classics and mathematics has become a kind of institution around which the feelings of those who have been educated under their influence have clung as around a political system whose existence is regarded as the palladium of the State. Propose to add anything or take away anything from this system, and you are immediately met with the demand to look at the long list of statesmen, warriors, scholars, and divines who have attained distinction under its influence. It is vain to reply that these worthies might have attained more distinction had they known more of natural science, or that probably their distinction was entirely independent of their knowledge of Latin, Greek, and mathematics. It is this feeling which meets us in the Universities and higher schools; and the unhappy tendency of the middle class to produce a miserable copy of this teaching brings down the sentimental objection to teaching natural science into the lower ranks. The only way in which this opposition can be overcome is by attacking the Universities. It is here that the natural sciences meet with their first rebuff. A very small proportion of the vast funds appropriated for education at Oxford and Cambridge are given to those who pursue natural science; and, although public opinion has forced both our Universities to be more favourable to the students of the natural sciences, it is very questionable whether anything short of legislative interference will induce the University authorities to get out of the groove in which they have run for centuries.

There are, however, schools which are not dependent upon the example of our Universities. There are the National Schools of England and Ireland, the British and Foreign Schools, and Girls' Schools everywhere. In these schools they do not pretend to teach Latin or Greek, why it is difficult to understand, for if the study of

the classical languages is of the value in training the mind that the advocates of their teaching assert, then the minds of all those who are not taught them must suffer, and thereby a great loss is incurred by the community. But let this pass. Some people believe in a male mind and a female mind, and other subdivisions of mind; so that what is strengthening and elevating to one class of mind is weakening and depressing to another. Thus our schools, as a whole, present an immense variety of subjects to be taught, but all agree in the exclusion of natural science. The real reason, however, why natural science is not introduced into the latter class of schools is no sentimental love of the subjects they teach, but the difficulty of teaching facts. Natural science cannot be taught by books; and the whole system of schooling, except in girls' schools where they teach sewing and music, is carried on by the agency of books. To teach the natural sciences, recourse must be had to *things;* books are of little or no use. Physics and chemistry must be taught by experiments; mineralogy and geology must be taught by specimens of minerals and rocks; botany and zoology by plants and animals. Neither teachers nor parents are prepared for this invasion, and the consequence is that little or no natural science is taught, even where the bugbear of Latin and Greek does not exist to frighten it away.

At the same time, whilst these difficulties exist with regard to teaching natural science in our schools, the study of natural phenomena has gone on during the last century with increasing rapidity. The Universities of the continent of Europe have in almost every instance acknowledged the position of natural science. In France and in Germany this has been remarkably the case; and in the latter country so great has been the progress, that she fairly ranks intellectually as first amongst the nations of the world. In England the necessity of natural knowledge for the exercise of certain professions, as that of the medical man and the engineer, has caused the foundation of schools from which have proceeded men who have cultivated the natural sciences with great success. We are not, therefore, without some practical knowledge of the beneficial effects produced by their study. That it may be safely introduced into our schools without injuring other studies is obvious from the fact that, when some branch of natural science has been taught in a school, the boys have been found not to have suffered in their knowledge of Latin and Greek. The result of a limited experiment at Rugby has been "that the school, as a whole, is the better for it, and that the scholarship is not worse." It is also found by the examiners in classics at the University of London and the Colleges of Physicians and Surgeons, that the point of excellence attained by the medical student who has to study natural science is not lower than that of general students who do not study natural science at all. If this be true, then it shows us that our present system confers

less benefit than if the whole of our scholars were compelled to study the natural sciences. This is also the experience of Germany, where the extensive study of natural science does not deprive her of classical students who may challenge the rest of the world for accurate criticism and profound scholarship.

Another reason for introducing natural science into our schools is seen in the fact that some boys have an innate aptitude for acquiring the facts of natural science, whilst they dislike or are entirely unfitted for classics and even mathematics. In this way the employment of scientific facts generally throughout the schools of the kingdom would assuredly be the means of raising up men who would devote themselves to this subject, and enrich the world with new discoveries and new applications of scientific principles.

We may say, however, that whatever may be the bent of a lad's genius towards classics and mathematics, a knowledge of the principles of scientific inquiry would go far to correct the acknowledged defects of such education. The observation of individual facts, the arranging them in laws, and reasoning from the known to the unknown, involved in the inductive and deductive processes employed by the natural philosopher, could not fail to provide a discipline of benefit to the scholar as well as the mathematician.

Another advantage of the cultivation of these sciences is, that it places the individual who studies them more closely in contact with the thought and experience of the age in which he lives. All the great activity of life depends much more on the progress of the natural sciences than the culture either of classical or mathematical knowledge; and a man in almost every position of life is placed more or less at a practical disadvantage who is not acquainted with the principles of scientific discoveries. Who is there with a knowledge of natural science that has not been grieved to hear an eloquent discourse marred by ignorance of the laws that govern the simplest natural phenomena! Who that has been examined before a Committee of the Houses of Lords or Commons, has not wondered at the ignorance displayed by our legislators of the commonest facts known to the scientific man! Again, how many of our scientific witnesses bring away from our courts of criminal justice impressions of the thoroughly false estimate that advocates, jury, and judges take of the simplest natural facts brought before them!

Another reason why the principles of natural science ought to be universally taught, is the fact that the daily health and life of mankind depend upon their obedience to the laws that govern the external world in which they are placed. The human body is so constructed that no one can understand the nature of the laws by which it exists without deriving benefit therefrom. A slight knowledge of the nature of the atmosphere in which we live, of the properties of heat, of the composition of materials about us, may

frequently be the means of saving life. In every occupation in which the human being can be employed, he must act in accordance with laws which have been discovered and understood by others, and every one must be directly benefitted by possessing such knowledge. To leave such a precious possession as this to the mere accident of a man finding out its value in after-life, is to play with the mercies of Providence, and to merit the punishment that attends the infraction of Divine laws.

In the last place, we may speak of the high intellectual pleasure afforded by that special exercise of the mind which attends the pursuit of natural science. There is, no doubt, pleasure afforded in poring over the beauties of ancient poets, and satisfaction given in the perfectly accurate results that follow the solution of mathematical problems; but we question if the gratification in either case is so great as that of contemplating the truths of physics, of chemistry, or of life. Especially are these studies ennobling in the highest degree when they are pursued with the feeling that all the great facts and phenomena of the universe are revealing the mind of God to man. The mind of the human being who has not studied the great laws by which God is governing and upholding the natural world, cannot be so capable of understanding the questions of man's responsibility and relation to God as he whose mind has, in the feeblest way, been led to contemplate God's nature in his works.

But supposing the point settled of the desirableness of introducing the study of natural knowledge into our schools, to what extent ought we to teach it, how ought it to be taught, and where are the teachers to come from?

With regard to the first question, a distinction ought to be made in the beginning as to the object of teaching the natural sciences at all. On the one hand, we may teach one branch or all these sciences for the sake of imparting desirable knowledge to the mind; or, on the other hand, we may use them with the object of training and strengthening the mind for action in the pursuit, generally, of the facts of the external world. It would not be impossible, we think, consistently with the time boys spend at our higher schools, to carry them through the chief branches of natural science in the course of their studies; and especially could this be done if the teachers were themselves skilled in science generally, and understood the relation of one subject to another. Unfortunately, the way in which science is pursued in England affords little chance at present of our seeing a body of skilled teachers who, whilst they could take a class successfully through one branch of subjects, should understand their relation and bearing to another class of subjects. The only profession that could supply this class of men is the medical; but then the man thus educated and fitted for

teaching, would make a much handsomer income by the practice of medicine than anything he could get by teaching science in schools. At the same time, it might be worth the while of some of our better schools to tempt men thus educated, by better salaries than are given to ordinary school teachers, to enter upon such a course of instruction.

By commencing the teaching with boys ten or eleven years old, they might be carried through the elements of all the natural sciences in a scheme like the following:—

First year: Experimental physics, embracing the laws of sound, heat, light, electricity, and the elements of mechanics.

Second year: Chemistry, embracing more especially the metallic elements, and a knowledge of the forms and composition of minerals.

Third year: The chemistry of the organic elements, and the consideration of those compounds which enter into the constitution of plants and animals.

Fourth year: The structure and physiology of plants, with the principles of systematic botany.

Fifth year: Comparative anatomy, and the general principles of zoology, and the physiology of the lower animals.

Sixth year: Human physiology, and anthropology.

This course of study might easily be varied, according to the judgment of the teacher; and the organic sciences might even be introduced from the commencement.

Such a plan as this could only be pursued with able instructors, and when ample time is given to acquire the knowledge imparted. It would be quite impossible to carry it out where only two or three hours a week are given to natural sciences. Five or six hours a week, for eight or nine months in the year, would be the least that would be required for such a course as the above.

This is one of the greatest difficulties connected with the working of natural science classes in schools, that none of the old masters are prepared to afford a sufficient amount of time for anything like giving a satisfactory amount of instruction. The writer once asked the master of a large school if his pupils were taught natural science, to which he answered, O yes! we teach all the natural sciences. "In what way?" it was asked, and the answer was, that an occasional course of lectures was delivered by distinguished professors from the neighbouring city. This gentleman would have been greatly surprised if a schoolmaster teaching the natural sciences were to propose to teach Latin and Greek by occasional courses of lectures. This is a fundamental error, if possible to be got rid of from the minds of men educated in classics and mathematics. They all regard natural science as an *amusement*, as something to be encouraged by way of relaxation in leisure hours, but never as the serious business of life. Until this notion

is thoroughly eradicated from the minds of our teachers, little or no progress will be made in the teaching of natural sciences.

But suppose we have only two or three hours a week to give to this kind of teaching, the question comes, What is the best use that can be made of them? Provided a competent teacher can be found, we have little doubt as to what subjects would be found most useful and advantageous. When the object is to give the mind a training in the principles of inductive science, there is no branch of knowledge more fit for this purpose than chemistry. The facts which it comprises are most varied, whilst their combination and arrangement admit of almost mathematical accuracy. The processes of observation and reasoning are called forth, whilst the experiments which must necessarily be performed excite the interest of the pupil to the highest degree. The facts when acquired are of the utmost practical utility. They lie at the foundation of most of the practical arts of life, and are the foundation of the higher sciences of vegetable and animal physiology. At the same time, care must be taken to place this science on its right footing. The pupils themselves should be made to perform the experiments. To teach chemistry by mere lectures with experiments is a defective method. To teach it by books without experiments is worse than useless.

There is another subject so daily useful, so important, that although not to be placed by the side of chemistry as a training science, it nevertheless demands the earliest attention, and that is human physiology. The information conveyed in this branch of knowledge is so individually valuable, that we think it might be successfully shown that no advantage obtained by any other kind of knowledge is so directly beneficial to mankind. It may no doubt be objected that physiology presents some of the most difficult problems that can be mastered by the human mind, and that as it is the last science that we have recommended to be taught in schools, under no circumstances ought it to be the first. It is no doubt true that it is better, where time can be given to the inorganic sciences, that they should precede physiology; but when it becomes a question about which of the sciences it is most beneficial to know something, then we have no hesitation in placing human physiology first. Nor is this science so difficult to teach as its complex problems would lead philosophers to think. Every pupil has in his own body the means of performing experiments, and can watch the functions which it is the province of physiology to teach. It is not proposed to teach physiology on account of its satisfactorily developing mental processes, but on account of its principal facts being necessary to be known in order to preserve health and save life. The great bulk of even educated people have little idea of the immense destruction of life that takes place every year through our

ignorance of the most ordinary laws that regulate human life. The rudiments of physiology could not be taught in nine-tenths of the schools of Great Britain without rebuking the disregard paid to its laws in the ventilation of rooms. the distribution of the hours of study and relaxation, the conduct of exercises, and a hundred other points connected with health. The homes of the poor and middle classes of this country are the constant sources of disease and death, not because of poverty or injudicious economy, but from sheer ignorance of the simplest laws by which God provides for the health and life of his creatures. The whole country is full of mourning for those who are stricken down with fevers and other contagious diseases, with scrofula and consumption, yet it can be demonstrated that the larger proportion of these diseases could be prevented by a knowledge of the preventible causes of disease and death. To defer teaching this subject till it can be taught at some distant time after school-days are over, is to forego one of the greatest advantages that can be conferred in teaching the natural sciences at all. This subject is seldom taught, and to no class completely, except to the medical profession; and although they have done nobly in urging upon the public mind the necessity of sanitary legislation arising out of their physiological studies, there is no public opinion to sustain sanitary law. Our legislators, our clergymen, our judges, our vestrymen, our electors, our people, are alike ignorant of the structure and functions of the bodies they live in, and disease and death stalk through the land from year to year with undiminished strides. The great hope of the sanitary reformer lies in the introduction into schools of the teaching such an amount of physiological knowledge as would form a public opinion that would second the efforts of the Legislature to secure for the people of England houses and homes free from the easily preventible causes of disease and death.

But, dwelling on this subject for a little, let us suppose that no effort is made in a school to introduce natural science as a means of training the intellect of the scholar; has not physiology a higher claim to attention than most of the subjects introduced into reading lessons? The favourite subjects for such exercises are history, geography, and natural history. Such reading is extensively introduced into our lower schools and into girls' schools. Everybody is agreed that children must read about something; and if this is the case, why should they not read about the structure of their own bodies and the functions on which their life depends? Surely it would be as well that the time for reading should be occupied in an account of Harvey's discovery of the circulation of the blood or Jenner's more important discovery of the prevention of small-pox by vaccination, as on the invasion of Britain by Julius Cæsar or the discovery of America by Columbus. Even the inveterate pre-

judice of those who think that nothing can be taught without the aid of books might be thus accommodated, and books on Physiology pointed out that might be read in schools, whether boys or girls are taught in these schools.

From what we have said, it will be seen how difficult it is to introduce the subject of natural science at all into schools. Where an individual teacher sees the importance of the subject it can always be introduced, but where there is indifference on the part of the teacher there is no pressure from without. We may say confidently that with regard to the success of any school, from a dame's school to an upper school or a University, it is a matter of perfect indifference to parents whether they teach natural knowledge or not. Hence we are driven to seek some power external to our whole scholastic system. There is no doubt our Universities possess this power. In a Report recently published by the House of Commons* it is stated that, "although no more than 35 per cent. even of the boys at our great public schools proceed to the University, and at the majority of schools a still smaller proportion, yet the curriculum of a public school course is almost exclusively prepared with reference to the requirements of the Universities and the rewards for proficiency that they offer." If this be the fact, it is then obvious that our Universities are really obstructive of the increasing intelligence of the age; and however much they are cultivating the "sweetness" of our youth, they cannot be said to increase their "light." This obstructive influence is felt not only in the higher schools, but in all educational establishments where English is spoken. The one great drawback to teaching natural science in the colleges of the United States of America is the example of the English Universities. Recently, in one of the largest Dissenting colleges in England the most feasible way of reducing the expenditure of the institution was in diminishing the modicum of teaching that had previously been attempted in natural science. The late principal of the Liverpool Collegiate Institute, when desirous of introducing natural science teaching into the school, was plainly told by the merchants of Liverpool that they only wished him to teach those branches of knowledge to their sons by which he had gained his own eminence. It seems very clear then that one great object to be kept in view in introducing natural science into education is to change the policy of those who rule in our Universities.

At the same time there are some cheering signs of movement both in our English Universities and in our public schools. At Oxford, Christchurch has opened a very complete chemical laboratory.

* Report of a Committee appointed by the Council of the British Association for the Advancement of Science to consider the best means for promoting Scientific Education in Schools. 1868.

Although there is little teaching of natural science in the colleges, Christchurch gives annually a junior studentship, Magdalen College a demy-ship, and Merton College a post-mastership for these subjects. There is also a scholarship founded by Miss Brackenbury at Balliol College for natural science; and another lady, Miss Burdett Coutts, has founded a geological scholarship for University graduates. There is also the Radcliffe travelling fellowship given to candidates who, having taken a first-class in natural science, are preparing for the practice of the medical profession. At Christchurch also there are two Lee's readerships in natural science, and recently fellowships have been given at Merton, Queen's, and Pembroke, for the same subject.

At Cambridge there is a natural science tripos, but little encouragement is afforded by the colleges for its study. There are scholarships at King's, Caius, Sidney-Sussex, St. John's, and Downing. The latter college has recently given a fellowship for natural science, and Trinity College has appointed a lecturer on the same subject. At St. John's there is a chemical lecturer and laboratory. In reference to Cambridge, the report above referred to says, "At present public opinion in the University does not reckon scientific distinction as on a par with mathematical or classical; hence the progress of the subject seems enclosed in this inevitable circle,—the ablest men do not study natural science because no rewards are given to it, and no rewards are given for it because the ablest men do not study it." The great question for the consideration of the people of England to whom these Universities belong, is, How is this vicious circle to be broken? In Cambridge there are also lectures on various branches of natural science adapted to a medical education.

The London University requires a certain amount of elementary knowledge of natural science in its matriculation examinations, which is classed under the heads of mechanics, hydrostatics, hydraulics, pneumatics, acoustics, optics, and chemistry. At the examination for B.A., a further knowledge of astronomy and animal physiology is required. The London University also gives degrees in science, and there is a B.Sc. degree, and two years after a D.Sc. is granted.

The College of Preceptors gives an honorary fellowship, for which one branch of science, either chemistry, natural history, or physiology, is required.

The Agricultural College at Cirencester has fifty pupils, who are engaged entirely in the study of natural science. There are professorships of geology, botany, chemistry, agriculture, and physics.

Amongst our high schools a beginning to teach natural science has taken place. At Rugby there are lectures on mechanics, geology, and botany, and these form part of the regular school course. A

Natural History Society has also been established at Rugby, to which the senior scholars are permitted to belong, the Transactions of which are before us, containing reports of papers and meetings held during the year 1868.

Natural science is encouraged at Harrow by a voluntary examination, to which all the boys are invited, and they are placed according to their merits. There is no systematic teaching, but many of the boys make great attainments in science, and some of them have already distinguished themselves in the scientific world. There is also a Scientific Society at Harrow, which meets at fixed periods under the presidency of one of the masters. A museum has been formed, and the masters speak highly of its beneficial influence in the training of the boys. At the International College at Spring Grove, the natural sciences are made a part of the general training of the boys. Competent masters have been appointed to teach these branches of science, and Dr. Schmitz, the intelligent head-master of the school, speaks very confidently of the success of the plan.

Intermittent attempts have been made to teach natural science in various other schools throughout the kingdom, but the want of determination in the masters and encouragement on the part of parents very often lead to the entire abandonment of any sustained efforts to proceed in this course. There seems little doubt that if young men of scientific tastes would fit themselves to become teachers in schools without applying themselves to the practice of some profession, they would find ample employment for their ability in tuition. They must, however, be prepared to insist on their own terms, and times and methods of teaching, as the condition of mind of the majority of those who undertake to teach the young, whether male or female, is utterly blank as to the nature, value, or methods of teaching any branch of natural knowledge.

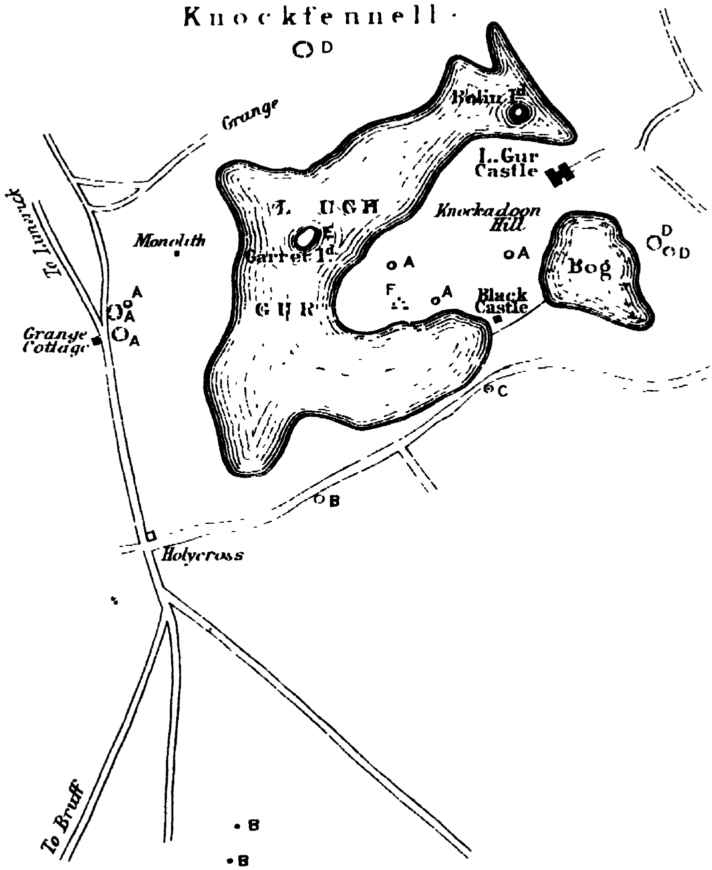
VI. THE PRE-HISTORIC ANTIQUITIES OF AND AROUND LOUGH GUR.

By Professor Harkness, F.R.S.

(With a Sketch-Map.)

At the distance of about 3 miles north of the town of Bruff, Co. Limerick, is an irregularly formed sheet of water known as Lough Gur. Including its islands and the district immediately surrounding it, this lake has been one of the most prolific sources of pre-historic remains in Ireland.

Near its margins there are several stone, and stone and earth circles, and from the abundance of remains of this character the lake has derived its name, which is, according to the statement of



A . *Stone, and Stone and Earth Circles*

B . *Cromlechs.*

C . *Cist.*

D . *Remains of Stone Forts*

E . *Crannoge.*

F . *Remains of Hut Enclosures?*

SKETCH MAP OF LOUGH GUR
AND THE
SURROUNDING COUNTRY.

Scale Two Inches to the Mile

Mr. John Fitzgerald, who is resident near it and who has a thorough knowledge of the Irish language, a corruption of Lough Cirgor, or the lake of the stone circles.

The most perfect of these circles is near the west side of the lake and close to Grange Cottage. This owes its perfection to Mr. John Fitzgerald, who has preserved it with most zealous care, and whose great interest in the pre-historic remains of the neighbourhood of Lough Gur has enabled him to recognize every spot near its margins where relic of this kind occur.

This fine circle is about 150 feet in diameter.* Internally it is made up of large blocks of conglomerate and limestone, the former being generally of greater size than the latter, and one of which, on the north-east side of the circle, is about 9 feet high, by 4 feet in thickness, and 6 feet in breadth. There are about sixty of these upright blocks of conglomerate and limestone, and these make up the inner portion of the circle.

Outside this circle of stones, and supported by it, is an earthen rampart, which at its crest is about 9 feet higher than the ground surrounding it. This rampart has a gentle curve outwards, except at one spot, and its base is about 34 feet wide. On the E.N.E. side of the circle a passage has recently been discovered by Mr. Fitzgerald, leading into the enclosed portion. This passage, which is about 2 feet wide, has the sides lined with flagstones. The area within the circle is considerably higher than the surface of the ground which surrounds it, and this area has been raised by artificial means, its level being less than 4 feet below the crest of the rampart.

A short distance northwards from this fine circle the remains of another are seen. This second one is entirely composed of blocks of stone. An old road runs through the western side of this second circle, the portions which remain are, however, sufficient to afford a knowledge of its original size. Its diameter is larger than the fine stone and earth circle at Grange Cottage, being 170 feet. Almost immediately adjoining this larger imperfect circle, and on its N.E. side, there is another, which is also composed solely of blocks of stone. This is a small circle, and is still very perfect. It consists of fourteen large irregularly shaped masses of rock, which have a squarer outline than the blocks forming the other circles. The diameter of this circle is only 55 feet.

A short distance N.W. of these three circles, and in a field adjoining the Limerick high-road, there are other traces of prehistoric remains. These occur in the form of a few large blocks of stone arranged in a double row. They may have originally formed

* For this, and the other measurements of the pre-historic remains around Lough Gur, I am indebted to Mr. Fitzgerald.

the western side of the large imperfect circle, having been removed from thence when the road was being made. There is also in the same field a large cup-shaped depression about 210 paces in diameter, but whether this is a natural or an artificial production there is not sufficient evidence at present to determine.

The eastern side of Lough Gur is margined by a very irregular outline, and the surface here is much bolder than on the western shore. Before the surface of the waters of the lake was reduced to its present level, a large island, about half the size of the lake, occupied the eastern side. This was, however, separated from the mainland only by shallow water in a narrow channel and boggy ground; it now forms a peninsula, and is known as Knockadoon Hill, the summit of which rises about 200 feet above the level of the lake, and the sides of which exhibit several bold rocky escarpments.

On the west side of Knockadoon, about 34 perches from the border of the lake, another stone and earth circle is seen. This, which is about 90 feet in diameter, is made up of a double ring of upright flaggy limestone blocks which have been obtained in the immediate neighbourhood, and which, when contrasted with the blocks forming the circles on the western side of the lake, are of small size. The interval between the outer and the inner row of flagstones is about 4 feet. The flags, as in the case of the large stone and earth circle at Grange Cottage, are placed very near each other, and the interval between the two rows is partially filled in with earth. Inside this circle are several detached blocks of rock of comparatively small proportions.

Another double stone circle filled in with earth occurs on the south side of Knockadoon, about 15 perches from the shore of the lake. This is somewhat smaller in size than the one just alluded to. It also has several detached blocks in the area enclosed by it. One of these, near the N.E. side, is a flaggy mass placed on its end in the ground, and being about 3 feet high, forms a small monolith. The antiquity of this monolith is well indicated by the weathered state of its surface, which is deeply eroded by atmospheric action. Mr. Day, F.S.A., Mr. Fitzgerald, and myself opened the ground immediately west of this monolith, and at the depth of little more than a foot from the surface discovered human bones. These consisted of fragments of ribs, fragments of bones of the arms, a nearly perfect lower jaw, a portion of the upper jaw, the frontal and parietal bones of the skull very nearly entire, with the temporal and occipital bones in a less perfect state. These bones had belonged all to one individual, a young person of from six to eight years of age. The bones of the head exhibited features of an

which is very obtuse, being 143°, and the relation of the condyle to the coronoid process, which are much removed from each other, giving to the hind portion of the jaw a form which belongs to a very aged individual, or to that of an infant, rather than a young person. The upper jaw is very prognathic in its outline; and this circumstance may have had some influence in giving to the lower jaw its singular modifications.

The form of the skull is strongly platybregmate, being broad and short, with the upper portion singularly flattened. Its greatest

Human Skull and Lower Jaw, discovered near Monolith, Lough Gur.

length is about $6\frac{1}{8}$ inches; and its greatest breadth, which is from the centre of the parietal bones, is about $5\frac{1}{2}$ inches. The width of the frontal bone is about $4\frac{1}{4}$ inches; and the circumference of the skull measured from the frontal sinus by the juncture of the sagittal with the occipital suture is about 18 inches. The frontal bone is peculiar in form. A line drawn along its ascending portion, and meeting another drawn along the flat upper surface of the skull, would form a right angle. The ascending portion of the frontal bone is about $1\frac{1}{2}$ inch high, and, curving rapidly over upwards for about an inch, meets the flattened surface of the head. The orbits have the upper portions small, with a very rounded outline. The bones of the skull are also very thin.

With these human bones a small fragment of the antler of a stag, about $1\frac{1}{2}$ inch long and $\frac{3}{4}$ of an inch in breadth, was found. Surrounding the monolith which marked this burial-place was a rude circle of small stones, about 8 feet in diameter.

A few yards west from the monolith in this circle, is a small patch, enclosed, also by a rude ring of small stones. This has an elevation of about 9 inches above the ordinary level of the surface, continued within this stone and earth circle. On opening this patch, and at the distance of about 18 inches beneath the surface a stone cist was discovered. The sides of the cist were composed of limestone flags, and the ends were also formed of the same materials. A flag of the same kind also covered the cist. This covering did not however extend over the whole of the chamber formed by the flags, the portion in which the lower extremities had reposed was uncovered. This, however, may have resulted from

stones breaking the lid, as above the cist several pieces of rock were found. The lower portion of the cist was formed of small portions of flaggy limestones, which had been arranged with considerable care, in the form of a pavement when the cist was being made.

Several fragments of human bones were met with in this cist. These consisted of fragments of ribs, a portion of a femur, two os calces, a portion of a lower jaw, and other fragments. The portion of the lower jaw had appertained to a young person of from six to eight years of age, and one of the os calces seems referable to the same individual. The other os calcis appears to have belonged to a nearly, if not quite, full-grown person; and the fragment of the femur, which had the epiphyses fully united, seems also to have formed part of the skeleton of an adult. The length and thickness of the thigh bone when compared with the corresponding bone of the skeleton of a modern full grown individual indicate a person of small stature.

The length of the cist also points out the small size of the body which had occupied it. This was not more than 4 feet 2 inches long; and as its depth did not exceed 18 inches, it is not probable that the body was buried in a crouching position.

The remains in this cist had been to some extent disturbed; but this had resulted from the burrowing of rabbits, the bones of which were found along with the human remains. Associated with these there occurred also fragments of the bones of swine. A portion of the right side of the upper jaw of this animal contained in the cist exhibited the last molar tooth, which was of a large size. The condition of this fragment indicated that it had long been buried; its state being similar to that of the human bones, and altogether different from the rabbits' bones, which have a very recent aspect.

Among the bony fragments of this cist were two upper incisor human teeth of rather a large size, and having the cutting surfaces considerably worn.

The two bodies in this stone and earth circle seem to have been placed originally in a north and south direction, the heads being towards the latter.

It would be premature, from these human remains, to draw any general conclusions as to the characters of the race which at an early period inhabited the shores of Lough Gur; and which buried its dead within the circles so abundant near this lake. Further evidence will probably be obtained from some of the other circles. So far, however, as these human remains enable us to judge, they tell us of a broad-headed people, with small eyes and of short stature, approximating more nearly to the present Fins and Laps than to any other race of men. And this circumstance is in accordance with many of the conclusions which have been arrived at concerning the pre-historic races of other countries.

Another small stone and earth circle occurs on the east side of Knockadoon Hill, at the distance of about 60 perches to the N.E. of the one just referred to. This, however, is in an imperfect condition.

Below the circle from whence the human remains were obtained, and to the west of this, about 35 perches, on the margin of the lake, there are several irregular-shaped small patches of ground enclosed by blocks of rock. One of these, which has an oblong form, is about 30 feet long by 18 broad. These enclosures occur in a small dell. They are tl . results of human labour, and have probably surrounded the huts of the ancient inhabitants of this shore of Lough Gur.

At the distance of about half-a-mile N.E. from Knockadoon Hill, on the farm of Ballycullen, a very large stone and earth circle is seen. It is about 155 feet in diameter; and this circle, both on its outer and its inner side, is composed of large upright blocks having earth in the interspace, the width of the circle being about 14 feet. In size this circle slightly exceeds the very perfect one at Grange Cottage. It is not, however, in so good a state of preservation, and has an earth fence intersecting it. It encloses within it another circle of the same character, which is about 49 feet in diameter, and which occupies a central position in the area embraced by the larger circle.

A few yards beyond the southern margin of the large circle another small one occurs. Its diameter is 35 feet; it is composed of flagstones, which touch each other. The area enclosed by this circle is raised to the height of about 3 feet above the surface of the adjoining ground. In this circumstance this small circle is analogous to the large one at Grange Cottage. The elevation of its interior has probably resulted from the falling down of a tumulus enclosed by the ring of flagstones. In the case of the raising of the level in the large circle several tumuli may have combined to produce this. In some instances these tumuli have probably fallen down from natural causes, but in many cases they have been destroyed by the hand of man under the impression that beneath them were buried hidden treasures.

That these several stones, and stone and earth circles near Lough Gur enclosed the places of sepulture of an early race is rendered probable, not only by the occurrence of human bones in them, but also by the circumstance that similar circles, which are found in other countries, afford evidence supporting the same inference. Local traditions have assigned them to a very different origin. By some they are regarded as Druid Temples; but this mode of disposing of their origin is of recent introduction into Ireland, and in general the peasantry look upon them as ancient fortifications. None of them bear a name indicative of a burial-place, and as there are no ideas prevalent that such is their nature,

they have probably belonged to a race of men antecedent to that from whence the Celtic population of Ireland has had its origin.

In a field a short distance to the north of the circles of Ballycullen, many stone cists containing human bones have been found. In this field there are at present no remains of circles. It is, however, probable that these did formerly here exist, and that their stones have been taken away for building cottages, several of which are near this spot.

Besides circles of stone, and of stone and earth, the neighbourhood of Lough Gur also contains the remains of Cromlechs. One of these is seen on the south side of the lake, at the distance of about a third of a mile E.N.E. of Holycross, which is on the Limerick high-road; and two others occur at the distance of about three-quarters of a mile south of this spot. These Cromlechs are locally known as "Giants' Graves."

On the south-east side of Lough Gur, a short distance from the ruin known as Black Castle, there is a stone cist of considerable size made up of large slabs of flaggy limestone. This, which is also known as a giant's grave, is 16 feet 8 inch. in length, 5 feet 5 inch. wide, and 2 feet 2 inch. high. Its covering still to a considerable extent remains, and consists of large heavy limestone flags. The object for which this was designed was most probably like that of the cromlechs, namely, for a place of sepulture.*

There is also on the western side of Lough Gur, near Grange, a very fine monolith. It consists of a mass of conglomerate, and is about 12 feet high by 7 feet broad, and from 3 to 4 feet in width. Its north-west side is flat, but its other sides are irregular in shape. It leans somewhat towards the S.E., and on this side, close to its base, the limestone is seen *in situ*. There are no carvings nor marks of any kind visible on this monolith.

The numerous stone erections already referred to do not exhaust the pre-historic remains of the neighbourhood of Lough Gur. On the summit of Knockfennell, a hill which rises above the northern shores of the lake, there are traces of a building made of large flat blocks of stone which had a circular outline, the diameter of which is about 42 paces. Traces of similar erections, which are even more distinct than that of Knockfennell, can also be seen on the summit of another hill, which is on the eastern side of a bog between this hill and Knockadoon. Here two circular stone erections can be detected, the most perfect of which is 142 feet in diameter.

* Local tradition has given to this cist, and to many others of the same kind, the Irish name of *Leabthacha Dhiarmada is Ghrainne*, or of the beds of Diarmaid and Grainne. The story of these individuals belongs to the mythical period of Irish history. The former is represented as the companion of Finn Mac Cumhaill, and the latter, a daughter of the monarch Cormac Mac Art, who, in order to escape being made the wife of Finn in his old age, eloped with Diarmaid, his young and handsome follower.

It consists of a wall in some portions about 4 feet in height and about 11 feet in thickness, composed of large masses of rock laid regularly one upon the other, and in the interior backed up by a great accumulation of smaller broken flagments of limestone; the latter being probably designed to produce a level surface immediately within the wall. The other circular erection, which is only a short distance from the one just alluded to, has a diameter of 138 feet, and is in a less perfect state.

These circular erections of stone, which occur on the hill-tops overlooking Lough Gur, have no mortar in connection with them. They appear to have been of the same character as the Staigne Fort in the Co. Kerry, and they probably formed strongholds. The positions in which they have been placed near Lough Gur have great natural capabilities for defence, and afford views over a large tract of country.

Although the race which erected the circular stone strongholds seems to have had no knowledge of the use of mortar, the builders of these strongholds appear to be referable to a period more recent than the constructors of the circles and other sepulchral remains which have been previously referred to.

Besides the numerous pre-historic remains which occur in the neighbourhood of Lough Gur, the lake itself also affords objects of antiquity of a similar character. Around Garrets Island, which is near the centre of the lake, and particularly towards its southern side, are to be seen many upright piles, especially when the surface of the lake is low. Garrets Island itself seems to be an artificial production, for the surface of it, which is only slightly elevated above that of the lake, is made up of broken fragments of rock, and these fragments are likewise seen extending from its shores into the water of the lake. Previous to the lowering of the lake's surface, which took place about thirty years ago, a large part of this island was under water; the only portion at that time visible was occupied by the ruins of a small castle or tower, which had probably been built by one of the Earls of Desmond. It is doubtful whether even this portion is not an artificial production; but in consequence of the rubbish from the fallen walls of this building, the surface which supports it cannot be seen, and there are circumstances connected with it which lead to the conclusion that it is not a natural surface.

At the time when the level of the lake was lowered, and the area of the island increased, the land laid bare was found to be covered with an enormous accumulation of bones. More than a hundred cart-loads of these bones were removed and sold to the dealers in such articles. For many years subsequent to the lowering of the surface of the lake, this spot continued to be a very prolific source of bones, for during the potato famine, the poor of the town of Bruff, when the water was low, obtained a scanty livelihood by collecting and selling bones from this locality.

The bones procured here consisted of the remains of *Bos longifrons*, the heads of which almost all exhibited a fractured front, produced by the blow which had killed them. Bones of the pig and goat were also found, the heads of which were likewise marked by broken frontal portions. Together with these were the bones and antlers of the stag, and some skulls, jaws, and other bones of a dog of a large size, and with an elongated muzzle. These dogs seem to have belonged to a race which was the progenitor of the now extinct rough-haired Irish greyhound. A few human remains were found along with the other bones. Some of these consisted of lower jaws, generally of a large size, and a heavy outline.

Besides bones, this island has been a very prolific source of stone implements in the form of polished celts. It has also yielded great quantities of bone pins and piercers. Stone discs about 3 inches in diameter and ½ an inch in thickness, beautifully rounded in outline, and with finely smoothed surfaces, have also been among its products. Similar discs have been obtained in other parts of Ireland in connection with Crannoges. For what purpose they served it is difficult to conceive, and nothing analogous to them has been found among the remains of the pile-dwellings of Switzerland.

Judging from its nature and the character of the several kinds of remains which Garrets Island has afforded, there is every reason for concluding that this island is the relic of a large Crannoge. History contains no authentic records of this, although some of the Irish Crannoges were occupied so late as the seventeenth century.

The portion of country around Lough Gur had been long in possession of the Desmonds before their forfeiture in the reign of Elizabeth; and the occupation of the Lough Gur crannoge must have been antecedent to the Desmond possession. That this crannoge of Lough Gur is of an ancient date, is proved by the implements which have been derived from it. Very few iron weapons have been obtained in it. Bronze celts of either the socketed or winged type, are rare in connection with it. The earlier and simpler form of bronze celt has been more frequently procured from it; and pure copper celts, the earliest form of metal, implements have been among the products of this Crannoge. These copper celts are of a ruder type than the earliest form of bronze weapons of the same character, and in outline they approximate more nearly to the antecedent stone celts.

It is, however, for stone implements that the Crannoge of Lough Gur is famous, and of these many may be seen in the Museum of the Royal Irish Academy, in some of the public museums of England, and also in several private collections.

NOTICES OF SCIENTIFIC WORKS.

THE POLAR WORLD.*

THE distribution of animal and vegetable life upon the surface of our globe is regulated, with remarkable exactness, by the quantity of sunshine which falls upon each parallel of latitude. In other words, the measure of solar energy which, as luminous, or calorific, or chemical force—to say nothing of electrical power—becomes active upon any spot of Earth, determines, not merely the life which shall exist upon that spot, but the variety of that life, be it vegetable or animal.

In the tropics, where

> "—— The long sunny lapse of a summer-day's light
> Shining on, shining on, by no shadow made tender,"

quickens the circulation of those fluids which are the life-stream of plant and animal alike, we find an exuberance of vitality. The vegetable world assumes a gigantic character, and bursts into flowers and fruits, in which nature's chemistry has produced the deepest dyes and the most luscious juices. The animal world also revels in an excess of life, and every passion is stimulated to the utmost by the influence of radiant forces, which are the beginning and the end of organized being. There men are

> "Souls made of fire, and children of the sun
> With whom revenge is virtue."

In the temperate zones all nature assumes a milder aspect; trees and shrubs, flowers and fruits, animals and man, are in the enjoyment of a more subdued existence; and every phenomenon, whether physical or physiological, is marked by the weaker influence of the solar power. As we advance towards the arctic or antarctic zones we find a gradual decline in the manifestations of vital power, and every organized creation assumes a peculiar character, which strikingly marks the struggle for existence under the difficulties of a diminishing quantity of light and heat. At last we arrive at a region where vegetable life appears limited to the reindeer-moss, and animal existence is restricted to such creatures as can make a snow cave their home, and support the heat necessary for life, by gorging themselves with fuel, in the shape of masses of fat, washed into their stomachs with large draughts of animal oil.

* 'The Polar World; a Popular Description of Man and Nature in the Arctic and Antarctic Regions of the Globe.' By Dr. G. Hartwig. Longmans, Green, & Co. 1869.

'The Polar World; a Popular Description of Man and Nature in the Arctic and Antarctic Regions of the Globe,' is devoted to a full consideration of those cheerless regions near the poles of our Earth, and the conditions of existence within their ice-bound circles. The frigid zone of the northern hemisphere is strikingly cut off from the temperate regions by belts of forest. We have a zone of evergreen coniferæ, which gradually shades off towards the north into a treeless waste. These wastes, known as "barrens" in North America and "tundri" in Russia, are produced by the ice-cold winds which sweep unchecked over the islands or the flat coasts of the Polar Ocean, and for miles and miles compel even the hardiest plant to crouch before the blast and creep along the ground. These "tundri" represent in a striking manner the peculiar phenomena of arctic life. In the winter an awful silence, interrupted only by the melancholy hoot of a snow owl or by the yelp of a hungry fox, reigns supreme over this vast expanse. But during this period of frigid repose, nature has been garnering her stores, and with the awakening spring she pours over air and sea and land a teeming luxuriance of life, which draws from the south an army of destroyers. "Eagles and hawks follow the traces of the natatorial and strand birds; troops of ptarmigans roam among the stunted bushes; and when the sun shines, the finch or the snow-bunting warbles his merry note. While thus the warmth of summer attracts hosts of migrating birds to the arctic wildernesses, shoals of salmon and sturgeons enter the rivers, in obedience to the instinct that forces them to quit the seas and to swim upwards, for the purpose of depositing their spawn in the tranquil sweet waters of the stream or lake. About this time, also, the reindeer leaves the forest to feed on the herbs and lichens of the tundra, and to seek along the shores, fanned by the cooled sea-breeze, some protection against the attacks of the stinging flies that rise in myriads from the swamps. Thus during several months the tundra presents an animated scene, in which man also plays his part. The birds of the air, the fishes of the water, the beasts of the earth, are all obliged to pay their tribute to his various wants, to appease his hunger, to clothe his body, or to gratify his greed of gain."

Dr. Kane observes, "No eider-down in the cradle of an infant is tucked in more kindly than the sleeping-dress of winter about the feeble plant-life of the arctic zone." Ere yet the destroying blasts of winter sweep over earth and ocean, the light and feathery snow has carefully covered up every organized thing; and in a state of repose, resting on or in the earth, kept warm by its snowy mantle, the plant and the animal await that awakening which comes with the rising of the sun above the horizon.

To the contemplative mind nothing can be more interesting than to read, in the pleasant words of Dr. Hartwig, of the way in

which the God of Nature has established his everlasting laws, by which the balance of existence is unerringly maintained. It is not possible, even if it were desirable, to follow our author through his several chapters—each of them interesting. All the lands which are spread out around the North Polar Ocean are described from the best authorities, and described in such a way that the reader believes them, as he reads, to be the result of Dr. Hartwig's personal observation. The plants and animals of the earth and seas are all graphically described; and the peculiar phenomena which attend their existence, under the extreme conditions of a polar winter and an arctic summer, are most fully and faithfully examined.

Living as we do in the temperate regions of the earth—complaining bitterly if our winter temperature falls much below the freezing point of water—we are astonished to learn from the narratives of the voyages of Belcher and of Kane, that their ships' crews endured the temperature of nearly 100 degrees below that point,—when chloric ether became solid, and strong chloroform exhibited a granular pellicle on its surface. Kane tells us, as examples of the readiness with which man adapts himself to the conditions of climate, that "George Riley, with a vigorous constitution, established habits of free exposure, and active cheerful temperament, has so inured himself to the cold, that he sleeps on our sledge-journeys without a blanket or any other covering than his walking-suit, while the outside temperature is $-30°$."

One of the secrets of healthful existence under such conditions is to be sought in the food taken into the stomach to maintain the internal temperature. Within the tropics where the solar heat excites the animal machine to the utmost, but small internal force is required, and there fruits and succulent vegetables are all that are necessary to maintain life. We advance to the temperate regions of this Earth, and then we find that man becomes a devourer of animal food, this diet becoming, of necessity, more and more carbonaceous as his dwelling-place is situated nearer to the poles. Within the arctic circle we find men feeding on fats, and the miserable Samojede is found eating pounds of blubber at a meal, and drinking quarts of seal oil.

Notwithstanding much that has lately been written asserting—at the same time as the materialistic philosophy is decried—that brute matter lives by virtue of mere motion, no one can study the relations of animals and plants to powers, forces, energies (call them what you will) which are external to themselves, without becoming convinced that light and heat and electricity are agents ever active in maintaining Life. Whether we examine life in the tropics or at the poles, we find provisions carefully, beautifully designed, to equalize the power acting within the living organism, with the force which is active from without upon it. Throughout

nature we see that life is maintained by the effort ever made to maintain the equilibrium of forces. A positive and a negative—a plus, minus—is found everywhere in the material universe, and, as the jar of Leyden owes its power to the effort it makes,—almost as if a sentient thing,—to equalize the conditions of its inner and its outer coating in relation to electrical power, so is there an analogous condition of this kind at work everywhere. This is perhaps more strongly shown in the phenomena of heat than of any other power, and nowhere is it more strikingly exhibited than in those regions where the deprivation of the sun for a long period reduces external nature to the extremity of cold. Those who can read this popular book with such a touch of philosophy in their minds as we have imperfectly indicated, will derive a double charm from the volume. Those who go to it merely for the interest which ever belongs to a well-written book on strange lands, will not be disappointed. They will find Man in what would appear to be the most wretched condition in which it is possible for him to exist, living with a certain amount of enjoyment; his very animal necessities are made so many ministers of contentment. Any one who will read with care the relation given by Dr. Hartwig, must rise from his task with his conviction strengthened that a superintending Providence alone could produce the remarkable results which astonish the traveller in the polar regions. To borrow some of the author's words, the influence on the development of vegetable and animal existence, of the long polar winter nights, and its fleeting summer, is amongst the most striking of natural phenomena. To picture Man waging the battle of Life against the dreadful climate of the high latitudes of our globe—as the inhabitant of their gloomy solitudes, or as the bold investigator of their mysteries—is to bring into striking contrast the highest and the lowest operations of mind, and to show how nearly equal are the animal conditions of him who is born amidst the eternal snows, and of him who would pierce the barriers of ice and knows what wonders lie enchained within them. Dr. Hartwig has written, for a foreigner, a book in capital English. He has, as he says, a "great variety of interesting subjects, embraced within a comparatively narrow compass," and he has conveyed much solid instruction under an entertaining form. To every one the 'Polar World' must prove a book of interest, and to many, especially to the young, it cannot fail to be a volume full of instruction.

SLEEP.*

THE "physical basis of sleep," as some of our modern biologists would perhaps be disposed to call the physiological phenomena which attend that mysterious condition of the higher animals, is admirably treated in the little work before us; and we cannot do better than draw attention to its suggestive pages, as we believe a close study of the subjec will throw fresh light upon those psychical powers of man concerning which so little is known and so much has been written.

In the first portion of his work the author explains the physiological cause of sleep with great clearness, and his theory appears to be borne out by our present knowledge of the subject. Popularly described, it is this: The brain is the organ of thought; when the brain is working, waste proceeds; when that waste has continued for some time, reparation is necessary; full vessels and a rapid circulation favour expenditure of the tissue, and a feebler and smaller current conduces to repair.† When the activity of the brain lessens, or when by a voluntary act it ceases, the diminution of the circulation is effected through the increased activity of the sympathetic ganglia which partially close the arteries that supply the brain, and put a stop to the physiological action which is necessary for the exercise of the mental powers. To facilitate the inactivity of the mind which is necessary to give rest and reparation to the brain, all the external avenues to the senses are closed, and so the mind is no longer disturbed by sensory activities, and is turned inwards, so to speak, upon itself only.

In sound sleep, then, it is to be presumed that little or no cerebral waste is going on, and when the reparation is complete we awake in the natural order of events. The author tells us that there are numerous causes of awakening, but they may "all be reduced to one ultimate action, namely, revoking the force of the ganglia upon the arteries, and reopening the arterial current throughout the brain." ‡

Many interesting phenomena connected with the sleeping state are ably discussed by the author. He treats of the entire absence of the power of hearing in some exhausted sleepers, as for example, the wearied soldier whose slumbers are not disturbed by the roar of cannon, so powerful is the hold of the sympathetic ganglia over the brain in sleep. Also of somnambulism, where certain senses are quite inactive and certain phases of the mind at rest, whilst others are wide awake:—"Some awakening of thought, consciousness, and will, recovered tactile sensibility, control over the muscles of the

* 'On Going to Sleep.' By Charles H. Moore: Robert Hardwicke.
† The author is here quoting Mr. A. E. Durham on the 'Physiology of Sleep.'
‡ P. 57.

body and limbs, an open eye and dilated pupil; but obscure vision or blindness, dulness of hearing or deafness, and withal, after relapsing into sleep and complete awakening, no recollection of the purposes or occurrences of the somnambulistic state;"* and this condition he accounts for by the theory that one set of arteries which supply a certain part of the brain are fully dilated, whilst another set which supply the remaining portion of the brain are partially closed, sleep being "due to contraction of *all* the arteries of the brain, and somnambulism to that of the carotids only."†

If the closure of certain arteries, which supply the brain with blood, brought about by nervous influence, is conducive to sleep, it follows that any cause which diminishes the quantity of blood circulating in the brain will have a similar effect; and the author says that "many examples of sleep arising upon the ligature, compression, or obstruction of the carotid trunks, enable us to conclude decisively that the diminution of the arterial current in the brain which occurs at the instant of sleep is no mere concomitant occurrence, but its actual cause." He might have adduced evidence of a kind more familiar to the general reader. Putting the feet in hot water causes an increased circulation in those members, and by drawing the blood from the brain, induces sleep. Sometimes a reaction ensues during the night; the feet become cold, the blood sets in the direction of the brain, and the patient awakes. On the other hand, the hydropathic treatment is in this respect more effective. When the feet are put into cold water and well rubbed, both whilst they are in the water and subsequently, an improved circulation is maintained throughout the night, and a sound unbroken sleep is the result.

Again, any person who finds it difficult to obtain rest, may probably succeed by lying down upon his back and doubling his pillow so that it fits into the back of his neck. The circulation is thus evidently impeded, for we have often found a drowsiness to supervene almost immediately on assuming this attitude.

Whilst the author thus describes the proximate causes of sleep under ordinary circumstances, he takes care to mention that the state may be banished by the exercise of the will; and that the will may also produce it. But this is nothing more nor less than saying that the mind is the active agent, and the brain the passive instrument; and exactly here it is that we believe his work to be so suggestive in regard to man's psychical powers. That in the long run "mens sana in corpore sano" is true, and that the exercise of active mental power requires a sound and well-ordered physical frame, no one will for a moment deny. But just as the most powerful physical exertions are sometimes successfully put forth by

* P. 49. † Pp. 52–55.

an exhausted man, the most violent display of emotion evinced by one who is prostrate, or as the most brilliant efforts of the intellect burst from an expiring thinker, so, too, the mind can at any time assert its supremacy over the active, or even the wearied instrument of its operations, and can say, "Obey me, so shall it be!" "I desire to sleep, although I have but just awoke." "I desire to sleep now, and to awake at such an hour." "You need rest, but I desire you to remain active. I *will* not sleep." All these things we can say to our brain and it must obey! How inconsistent are these facts with the teachings of some modern physiologists, who would have us believe that the brain is a self-acting thinking machine, and originates the thoughts which it conveys.

We have no space to deal with other phases of the subject, such as the physical causes which exclude thought in spite of the will, rendering the machine incapable of action, but trust that we have said enough to show how deeply interesting and suggestive is the unpretending little work which has served as the basis of these observations.

On Molecular and Microscopic Science. By MARY SOMERVILLE. 2 vols. Murray.

THE attention which has been given of late years to the study of the molecular constitution of matter, and the interesting discoveries which have been made, have evidently suggested to our remarkable countrywoman the work before us. Unless we are greatly mistaken, Mrs. Somerville's original idea was to show, by collecting all the evidence within reach, that the molecule of inert matter and the organic molecule were influenced by the same set of forces or energies. As we see the inorganic group of atoms compelled to assume a determinate form under the influence of forces which always manifest, to a greater or a less extent, polarity, so we discover that the organic molecule—the primary cell—is equally the result of the operation of similar physical agencies. The materials which constitute the amorphous mountain masses, whenever they are free to arrange themselves, assume a geometric form. The microscopic examination of any rock, indeed, exhibits the struggle between the desire—if the word may be used in reference to brute matter—to crystallize, and the mechanical power, pressure, which prevents it. Remove in the slightest degree the pressure, and the inert molecules undulate into form, and crystallizations appear—a mute prophecy, as Coleridge has it, of the coming vegetation. All the elements found in the organic creation, whether we take for our examples the vegetable or the animal world, are discovered in the inert, inorganic constituents of our planet. By what processes are carbon, nitrogen,

hydrogen, and oxygen, which we find so abundantly in the three ancient elements, Air, Earth, and Water, compelled into the muscular matter of an animal or the ligneous structure of a plant? May we draw from our modern science the conclusion that the fourth ancient element Fire—we mean thereby the empyreal forces which are gathered into the sunbeam—is the *creative* agency. "Where there is Light," said Lavoisier, "there we have organization and Life; where Light cannot penetrate, there death for ever holds his silent court."

The elementary constitution of matter, and the relations, so far as they are known, between Force and matter, are first considered by Mrs. Somerville. Then she examines all that has been done by spectrum analysis, as we believe, desiring to shadow out the influence of the radiant powers in determining organized forms. Our authoress then plunges (we can find no other word so truly expressive of the fact) into the microscopic structure of the vegetable world and of animal organisms. Here is the great defect of this work. There is no real connection between molecular science and microscopic investigation. The first examines with all the subtlety possible, by the aid of experimental induction, the phenomena dependent upon atmospheres of force enveloping the ultimate atoms of matter; the second observes the vast variety and the infinite beauty observable in the microscopic forms of life. But, although the microscope may teach the observer that a particular organic mass is but a wonderfully constituted aggregation of cells, that instrument can never advance him to a knowledge of the mechanical operation of the osmose forces by which the functions of life are carried on, nor to any appreciation of the value of the solar energies in producing an equivalent of organized form. It was a mistake, in the present state of science, to connect the two. Whatever may have been the first idea of the authoress, she must feel that the molecules have given her one set of links, and that the microscope has developed another. They may appear to have relations to each other; but a great many links are wanting, and we have two ends of a broken chain.

These volumes exhibit a remarkable amount of industry in the collection of facts. They show an equally remarkable clearness in the appreciation of the value of those facts, and they prove that the weight of years has fallen lightly upon the head of the lady who so long ago translated the Astronomy of Laplace, and examined so satisfactorily 'The Connection of the Physical Sciences.'

We were not honest if we allowed ourselves to be betrayed by our admiration for this lady into a false praise of her labours. These volumes are fragmentary: they are made up of the facts, and the fancies, of experimental and speculative philosophers. Neither the molecular science nor the microscopic observations of these volumes must be taken as reliable guides to the truth. They

may be used with advantage as indicators of the world of wonders which is to be found in the infinitely minute; and there is a charm in the variety of the work which will render it valuable as a means of interesting young and intelligent minds in the study of Natural History.

A Course of Six Lectures on the Chemical Changes of Carbon. By WILLIAM ODLING, M.B., F.R.S., Fullerian Professor of Chemistry, Royal Institution. Reprinted from the 'Chemical News,' with Notes by WILLIAM CROOKES, F.R.S., &c. Longmans, Green, & Co., 1869.

For many years it was the custom of the late Professor Faraday to deliver, during the Christmas holidays, a course of lectures on some branch of science. These were professedly addressed to children; but the back seats and galleries of the lecture-theatre were generally crowded with adults, many of them well known in the scientific world, drawn thither by the charm of the great philosopher's eloquence and manipulative skill. During the many years that this custom was observed, almost every branch of physical science was thus expounded, and it must always be regarded as a misfortune that most of these lectures have passed away without a record. The last two courses which Faraday delivered, namely, those "On the Physical Forces," and "On the Chemical History of a Candle," were fortunately published by Mr. Crookes in the pages of the 'Chemical News,' the words as they fell from the speaker's lips having been taken down by a skilful shorthand writer.

For a few years Dr. Tyndall delivered the Christmas Lectures, and we are now glad to find that Dr. Odling, the worthy successor to Faraday in his chemical chair, has followed his predecessor's example in continuing them. As in the former cases, the course of lectures, taken down in shorthand, originally appeared in the 'Chemical News,' and they have now been reprinted from that journal in the form of a handsome volume of 162 pages, with preface and notes.

The author's arrangement of the subject is most logical, and the manner in which he starts from marble—a brittle solid—and gradually unfolds its chemical history before the audience, is a model for all lecturers on science. Dr. Odling starts with no assumption of knowledge on the part of his audience. Every step taken is the logical sequence of that which preceded it, and whilst explaining the phenomena with all that vivacity of style and clearness of expression for which the lecturer is so distinguished, he does not fail to supplement his explanation by a decisive experiment. He first shows that marble effervesces when an acid is poured on it, this effervescence being due to the liberation of a particular kind of air

or gas. The same kind of air is then shown to be evolved from marble by the action of a red heat, quick-lime being left behind. The properties of lime are then shown; its evolution of heat when slaked by water; its non-effervescence on being treated with acids; its solubility in water; its combination with the air previously evolved from it to reproduce marble. These phenomena are illustrated with ample experimental evidence, until the audience are thoroughly familiar with the connection existing between quick-lime, marble, and the gas evolved from it. The properties of this gas are then explained; the extinction of ordinary flames in it, and its power to support the burning of other bodies are illustrated; but it is not until a piece of carbon is actually obtained before the audience by heating sodium in the gas which has just before been evolved from a piece of marble, that the lecturer makes use of the term carbonic gas, or leads any one to suspect that carbon in any form is associated with marble. Having proceeded so far, the lecturer shows how carbonic gas may be obtained in other ways, and the consideration of this subject naturally leads to the composition and properties of air and the subject of oxygen and oxides, the ordinary experiments with this gas being varied in a somewhat novel manner. These subjects occupy the first four lectures. The fifth is devoted to other forms of carbon, such as graphite and the diamond, and liquid and solid carbonic gas; whilst the concluding lecture treats of carbonic di-sulphide, carbonous oxide, and the unburning of carbonic gas by vegetation. From this part of the subject we are tempted to make one or two quotations, which will serve to show the clearness of expression with which Dr. Odling is so happily gifted. "If you reflect a little, I think you will come to this conclusion: that substances which grow—vegetable substances—are all of them destined ultimately to become burnt, or to undergo a change equivalent to burning. A great deal of wood, for instance, is chopped up and used for fire-wood; a great deal more is used for building ships, for forming the interior portions of houses, and making furniture. These ships and houses and furniture last for a certain time; they gradually pass from an honourable into a dishonourable condition; old furniture is put into the lumber-room; the disabled ships are broken up and destroyed; and at last they go to the fire, where the carbon becomes oxidized or converted into carbonic gas. But there is a great deal of vegetable matter which never undergoes this burning. In the autumn a large quantity of leaves fall to the earth, and there undergo some sort of change; this change is in fact a very slow burning, but without the phenomena of ignition which we see in the case of a fire, although the leaves are converted into carbonic gas or oxidized carbon. . . . . . But a great quantity of vegetable substance neither undergoes burning nor decay, but is eaten. We know that cattle feed largely

on corn and straw, and we ourselves consume much wheat and other grain. In these instances, although the vegetable substances do not, strictly speaking, *decay*, yet they undergo another form of the process of oxidation by which burnt charcoal is produced. . . . In this case, the carbon, instead of having been burnt in a furnace, has simply been burnt in our bodies, thereby rendering them warm, just as when it is burnt in the fire it warms a room."

Respecting the unburning of carbonic gas the author illustrates the phenomena of growth and vegetation in the following words, which, whilst they place this subject in a clearer light than we have ever before seen, show at the same time how intimately the conservation of force is bound up with the conservation of matter. "If the sun, instead of shining on the plants which grow on the earth's surface, were to shine entirely upon the stones, it would heat the atmosphere a great deal more than it does. As it is, a portion of the sun's heat disappears. What then becomes of it? It is absorbed by the vegetation. The amount of heat absorbed by a growing piece of wood in unburning the carbonic gas of the atmosphere into charcoal and oxygen is exactly the amount which the piece of wood is capable of giving out when its carbon is reburned in the air; and accordingly when we burn coals or wood or peat upon our fires, or consume bread and oil and wine in our bodies, and thereby produce a considerable amount of heat either in the fires or in our bodies, we are really manifesting once more in the form of heat, the sun's rays which years and years before shone upon the plants from which those substances were derived."

When we remind our readers that the chemistry of carbon includes the chemical history of all animal and vegetable substances, it is evident that there can be no better introduction to the study of that grand science for a youth whose tastes lie in that direction than the careful perusal of Dr. Odling's Lectures on the Changes of Carbon.

CHRONICLES OF SCIENCE,

Including the Proceedings of Learned Societies at Home and Abroad; and Notices of Recent Scientific Literature.

1. AGRICULTURE.

A most instructive and suggestive paper "On the Condition of the Agricultural Labourer" appeared in a recent number of 'Fraser's Magazine.' The decennial statistical records of the Registrar-General and the annual agricultural tables issued by the Board of Trade are used in it with great ability to teach both the leading facts regarding the labourers in our fields, and their relations to the corresponding facts regarding the labourers in our mines and in our workshops. The main features of agricultural practice and experience in the several English counties are also cleverly marshalled, and exhibited so as to explain the distribution of the agricultural labourer over the country. The whole is not only discussed in a very well-written essay, but uncommonly well depicted and presented to the eye in diagrams and maps. In one set of curves, for example, the percentages (at the several ages) of the whole number of labourers employed on land and on coal and iron respectively are shown; and we see at a glance that a larger proportion of all that are so engaged is of the middle age in the cases of coal and iron than in the case of land. The curves of coal and iron labour stand higher between the ages of eighteen and forty-five; and the curve in the case of land labour stands highest over the early years and over the later years. The explanation is that many of the boys of the farm leave it for the workshop as they become men, and return to it as they approach old age and begin perhaps to look out for a maintenance at the expense of their parish. Other diagrams illustrate the quantity of agricultural labour employed per acre in the several counties; and it appears that it is not only the amount of arable land in a county which determines the quantity of agricultural labour employed per 100 acres,—that depends rather on the quantity of live stock which is on the land, and especially on the quantity of dairy stock. Lancashire and Middlesex employ more labour than other counties, notwithstanding their large proportion of grass land, no doubt because of the great quantity of live stock which their agriculture maintains. There is however a good deal of difference in this particular, also due to the character of the soil. Light lands are suitable for sheep farming, and sheep require but little care. On heavier soils cattle must be

kept; and on arable land they must be kept in yards and stables, and this necessitates much labour. A portion of the essay is devoted to a discussion of the improvements in agriculture which are required in the interests of the labourer. We are not at all disposed to lament the decrease in the number of those employed in fields; which is the leading fact before reviewers of this subject. We may depend upon it that any tendency of this kind is the result of individual action on the part of those immediately concerned, which is prompted by the sharpest and most anxious insight into self-interest. If the sons of agricultural labourers are as a rule gradually leaving the country for the town, we should accept it not as a thing necessarily to be lamented and if possible prevented; but rather as a proof that the condition of the labourer in towns is declared to be better than that of the labourer in fields by that jury whose verdict, more than that of any other, is likely to be trustworthy. When it shall have become the interest of the farmer to employ more labour, and when he shall have been driven by the force of circumstances to pay a higher wage, then the course of events will alter; and we may possibly have hereafter to report that cottages and gardens, and education and wages in country places, are together offering attractions to the labouring man superior to those which are presented in the circumstances of our town population. There can be little doubt that when that happens, we shall have a longer lived and healthier race upon the whole than we have at present. That is an advantage affecting especially the very young, in which the town labourer is unquestionably at a great disadvantage.

The current number of the 'Journal of the Royal Agricultural Society' contains reports of several experimental researches, conducted by Dr. Voelcker into the effects of various manures on clover and grass. His observations on the clover under treatment, are that nitrate of soda is about as efficient in the production of growth as sulphate of ammonia—that common salt is variable in its effects, in one year producing growth and in another inefficient—that the heaviest crop is obtained from a mixture of superphosphate of lime and muriate of potash—that where salts of potash have been used the second cutting of clover weighs more than the second cutting of the unmanured crop, whereas when nitrate of soda has been used the second cutting is inferior. These are the results in the special instances reported; but every agricultural fact is the result of so many circumstances besides those to which the attention of a reporter is especially directed, that it is never safe to give to particular examples the value of a general law. In the case of ordinary grass-land, Dr. Voelcker found that the direct application of quicklime was injurious—that salt and quicklime produced no effect whatever—that mineral superphosphate and

crude potash salts gave but a small increase of growth—that Peruvian guano yielded a large increase; and that the heaviest crop of grass, amounting to nearly twice the weight of that upon the unmanured plot, was obtained by a mixture of superphosphate and guano. The experiments were made in 1867, but the summer of 1868, when they were repeated, was so hot and dry, that no trustworthy results were then obtainable. It is plain that the effect of a very soluble manure like salts of potash or ammonia depends very much upon the circumstances of the application. If applied when the plants to be affected by it are in the condition of rapid growth, the result may be very great; while, if applied in winter when no immediate use could be made of them, it might be altogether washed to waste before the time of growth came round. Soluble top-dressings, therefore, ought to be applied at the commencement, or during the course, of the time of rapid spring growth, in order that their maximum effect may be obtained.

2. ARCHÆOLOGY (Pre-Historic),

And Notices of Recent Archæological Works.

The most important recent publication in connection with this branch of science is the grand work by Mr. James Fergusson, F.R.S., 'On Tree and Serpent Worship: or, Illustrations of Mythology and Art in India, in the First and Fourth Centuries after Christ; from the Sculptures of the Buddhist Topes at Sanchi and Amravati.' Published and prepared under authority of the Secretary of State for India in Council, this book enjoys the advantages of the printer's, engraver's, and photographer's skill, and justice is done in the ninety-nine quarto plates and twenty-one wood-engravings of these rare and beautiful remains of early Indian architecture so ably described by the author in the text. Mr. Fergusson traces out the origin, rise, and spread of the Buddhist religion in India, and the founding of monastic establishments for the reception of religious devotees, varying in size from those capable of containing two or three monks to several thousands.

The great interest about these edifices is that before the time of Asoko, 250 years before Christ, there was not in India a single scrap of a building worthy of the name. With the establishment of Buddhism, architecture first began to be manifested, and its very earliest and crudest designs can be traced in church caves, some of which are older than the Christian era. But probably the most interesting of all the Buddhist monuments are the topes or tumuli. These belong to two types,—the early period, represented by the Sanchi tope, in which one readily traces the imitation of the ante-

cedent wooden constructions, carefully copied in stone and but little altered; and the latter period, by the Amravati tope, which from its beauty and elaborate workmanship clearly shows the development in architectural art which had taken place between their erection.

The Buddhist religion, like most forms of worship, became in process of time corrupted from its original purity and simplicity, and Mr. Fergusson traces in the sculpture upon these monuments the gradual introduction and ultimate adoption of tree and serpent worship with the religion of Buddha. This tree and serpent worship is found not alone in India, but appears to have prevailed in the world from the earliest times. The author traces in the account of the tree and serpent in the Book of Genesis a remnant of that old worship, and he shows how it had found its way among the Greeks and Romans, thence to Scandinavia, and every part of Europe. Tree and serpent worship prevails in Africa to a large extent, and there is even evidence of its existence in America.

The application of Architecture as an aid to Ethnology can hardly be too highly estimated, especially when the task of working out devolves upon so able and distinguished a scholar as Mr. Fergusson, and we hope that further researches may yield further results as worthy of publication as is the present volume.

The illustrations to this beautiful work must be seen and carefully studied, and they will be found well worth examination. An old Indian officer observed to the writer, "India is full of grand architectural monuments, but they all belong to the native races: if the English were driven out to-morrow, the only monument they would leave behind would be *empty bottles!*"

The appearance of two more parts* of Messrs. Lartet and Christy's *Reliquiæ Aquitanicæ* completes the description of the human and animal remains from the Cro-Magnon Cave. The human bones belonged to an old man, a woman of thirty-five or forty years of age, and an adult man. One of the old man's thigh-bones presents traces of an old wound, received possibly in a fight, and the skull of the woman had been penetrated through the left frontal bone, apparently by a blow from a stone axe, which seems to have caused death after about twenty days, as around the hole is a deposit of finely porous bony matter, which must have required fifteen to twenty days for its production.

These circumstances, coupled with the facial characters and the powerful muscular impressions on the limb-bones, stamp the Cro-Magnon people as a violent and a brutal race; but their brains do not lack size and good proportions, so that we may well infer from this fact and from their ingenuity in the fabrication of weapons, and

* Parts viii. and ix.

the skill they displayed in their drawings of animals, that—savages as they undoubtedly were—they were no inferior race, but possessed of both physical strength and great ingenuity, which placed under more favourable conditions might have brought forth good results.

One of the animals whose remains have been found in six or seven different localities in the caves of Central and Southern France, deserves special notice. It is that of the Saïga Antelope, now found living on the eastern slopes of the Ural Mountains and the shores and islands of the Sea of Azof. Strange to state, only the horncores have been found, yet their peculiar form convinced M. Lartet that his determination of these remains as belonging to the Saïga was correct.

He suggests that the long, solid, and pointed horns of the Saïga, so well adapted to make formidable weapons, may have been obtained as articles of barter from a more eastern people, with whom this antelope was indigenous. Numerous plates (accompanied by descriptions) of stone implements and Reindeer-horns carved and perforated, for use or ornament, increase the interest of this work, a lasting memorial of our much-lamented countryman Henry Christy.

A cromlech in Jersey, recently opened, was found to contain, besides broken pottery, nine urns, osseous remains, charred wood, and ashes, a stone amulet (drilled with two holes), and a few flint flakes. Several ancient bronze wedges were picked up near the same spot.

Mr. J. W. Flower read a paper before the Geological Society, on 28th April, "On the Distribution of Flint Implements in the Drift, with reference to some recent Discoveries in Norfolk and Suffolk." Mr. Flower suggested that the implements belonged to a period antecedent to the true River-gravels, when the valleys of the little Ouse and other tributary streams were tidal: to this Messrs. Prestwich, Ramsay, and Evans demur, holding that all the gravels with flint implements are of fluviatile origin. Mr. Searles V. Wood, jun., however, to a certain extent supports the view taken by Mr. Flower, and considers a part of these gravels at least to be due to tidal action. Mr. T. C. Wallbridge, at the same meeting, mentioned (in a paper "On the Geology of Hastings County, Canada West") that in a deposit of Hæmatite, called the "Kane Ore-bed," ancient workings were discovered—apparently those of Indians, who may have used the ochre for war-paint. He met with bone needles and other objects of human workmanship, which he exhibited.

Ethnological Society.

Part I. of the new Quarterly Journal of this Society made its appearance in April last, edited by Professor Huxley, F.R.S. (the President), and a Committee of the leading members of the Society. The number contains articles by (1) Col. A. Lane Fox, Hon. Sec. E.S., "On some Flint Implements found associated with Roman Remains in Oxfordshire and the Isle of Thanet," tending to prove that there must have existed, during the Roman period in this country, a class of people who employed flint tools such as we are in the habit of associating with a very early condition of human culture. The interblending of civilized and barbarous conditions in Romano-British times occurred as certainly as it does in South America at the present day, where every shade of gradation may be observed between the highest condition of civilized life and that of savages armed with bows and poisoned arrows and wearing lip-stones. In the Gold-ornament Room at the British Museum may be seen an Etruscan necklace of most elegant workmanship in gold, from which is suspended a flint arrow-head of the same pattern as one of those figured by Col. Lane Fox from Oxfordshire.

(2.) Mr. H. Howorth gives Part I. of an "Essay on the Westerly Drifting of the Nomads from the Fifth to the Nineteenth Century," in which he traces the immigration and spread of the various nomade races which have overspread the great plains and steppes of Southern Russia and Poland, and the plains of Hungary, Persia, and Asia Minor.

(3.) Col. A. Lane Fox gives an account of a bronze spear with a gold ferule and a shaft of bog-oak, 6 feet 1 inch in length, the bronze head 1 foot 4 inches from the point to the base of the socket, obtained from Lough Gur, County Limerick.

(4.) Mr. Hyde Clarke contributes a paper "On the Proto-Ethnic Condition of Asia Minor," and traces out the early history of the Khalubes and other hill-tribes engaged in mining and smelting ores, and endeavours to correlate them with the Yuruks inhabiting the mountains of Western Asia Minor at the present day.

(5.) Sir John Lubbock's account of some stone flakes of a very rude description, from the Great Flat between Table and False Bays, Cape of Good Hope, is interesting from the fact that, although the African races are almost all in a very barbarous state so far as relates to social conditions, yet a knowledge of rude metallurgy has been long and widely spread throughout Africa, and we know, as yet, scarcely anything about the stone implements which, no doubt, here, as elsewhere, preceded the use of metals.

(6.) Mr. H. M. Westropp's paper "On Cromlechs and Megalithic Structures" is an endeavour to prove that such archaic remains are peculiar to no people or race or country, but are the

result of an endeavour to secure a permanent place of sepulture by a people in a rude and primitive state of civilization. To this conclusion Col. Lane Fox demurs, and in a very able criticism shows, first, that the megalithic monuments are peculiar to certain regions, as Ireland, Britain, Denmark, Sweden, Normandy, the South of Spain, the North of Africa, India, &c.; and secondly, that they had many other uses besides that of marking and commemorating the interment of the dead; such as, for instance, places of assembly and council meetings, of judgment, of worship (not connected with the dead). Col. Fox instances the frequent interment in sacred edifices at the present day as a case in point to prove that the worship of the dead may have had no actual connection with the stone circle, although the dead may be buried within its radius.

(7.) Dr. Hooker contributes some interesting notes on Child-bearing among the Aborigines in Australia and New Zealand.

(8.) Mr. Layland's notice of the Cave-cannibals of South Africa has too much of the "Traveller's Tales" look about it. Speaking of one old savage, he says he had "a 'devilled kidney' or 'boiled missionary' look about him." Such remarks are hardly in accord with a scientific journal.

Mr. J. H. Lamprey, the Assistant-secretary and Sub-editor to the Society, suggests an ingenious method by which photographs of natives, taken in distant countries, may be rendered of greater value for purposes of comparison and study. The subject to be photographed is placed against a background formed by a frame of wood, 7 × 3 feet, neatly divided by strained threads of silk into 2-inch squares, thus giving an index-scale for the entire figure easily applied to any subject.

Many minor papers, notices, and reviews are contained in this number of the Journal. It starts well at least: let us hope its succeeding numbers may prove equally worthy of notice.

Anthropological Society.

Many of the papers read before this Society, and published in their Journal, are of a metaphysical or physiological character.

Dr. James Hunt communicates a paper "On the Character of the Voice in the Nations of Asia and Africa, as contrasted with that in the Nations of Europe."

Dr. John Beddoe, Pres. A.S.L., gives the result of personal observations on the physical characteristics of the people of Brittany.

Dr. Charnock, Vice-President, describes a menhir or dolmen lying broken on the ground at Locmariaker, in Brittany, which, when erect, must have measured 72½ feet.

Mr. A. L. Lewis, who also describes the same place, adds an account of Gavr Inis, or Goat's Island, situated in the Morbihan

Sea, and celebrated for its chambered tumulus, the chamber and gallery of which are together about 70 feet long, 5 feet high, and 3 feet wide at the entrance, increasing gradually to a height and width of from 6 to 8 feet. The surfaces of the upright stones forming the walls are nearly all covered with incised ornamentations, composed chiefly of segments of circles interspersed with wavy lines, resembling somewhat the Northumbrian rock-inscriptions and those of the tumulus of New Grange, Ireland.

Dr. Hunt reports the results of an investigation of the megalithic monument of Carnac, in Brittany, controverting the statement of Sir John Lubbock that Avebury and Stonehenge were the two largest monuments of their class in Europe, and insisting on the superior proportions of Carnac, which also differs in many respects from Stonehenge. Dr. Hunt denies that there is any proof of the contemporaneity in construction of Carnac, Avebury, and Stonehenge.

Mr. L. Owen Pike contributes a singular paper "On the alleged Influence of Race upon Religion," in which the author expressed his conviction that any race might, to all appearance, hold any creed, and, in conclusion, that, although there may exist certain race-elements in the religion of every people, they are of minor importance, and cannot be defined in the present condition of language and psychology!

Dr. John Davy, F.R.S., gives a paper on the Negro, chiefly in relation to industrial habits, vindicating the negro race against the unjust charge of being inveterate sluggards.

Dr. Charnock, F.S.A., describes the peoples of Transylvania, which country embraces no less than fourteen distinct races, a most interesting region to the Anthropologist.

Mr. H. Westropp, "On the Mythic Age," attempts to show the intellectual unity of the human race from the almost universal prevalence of similar myths among early and uncivilized peoples in remote countries.

Mr. G. Harris, F.S.A., attempts the difficult task of explaining "the Mental and Moral Distinctions occasioned by Difference in Sex,' and Mr. J. McGrigor Allan the equally daring attempt to show "the Real Differences in the Minds of Men and Women." The former writer honestly observes that there are extensive differences which no artificial attempts can lessen; but each sex has its proper sphere of exertion and duty in which it excels. The latter writer evidently places women on a very much lower physical and moral platform than man, and whilst charging women with contending for empire and seeking masculine privileges, uses rather unfair arguments. Some of his assertions are palpably inaccurate, as, for example, that "women are *always* more or less invalids."

3. ASTRONOMY.

(*Including the Proceedings of the Astronomical Society.*)

After the failure of Brorsen's comet to make its appearance at the appointed time, astronomers may think themselves fortunate in the re-discovery of Winnecke's short-period comet at its present return to perihelion. M. Winnecke himself re-discovered the comet at Karlsruhe. He describes it as large, but not bright. By the time these lines appear it will have become concealed from view through its proximity to the sun. We do not hear that any observations of importance have been made upon it, nor had Mr. Huggins, at the time of the last meeting of the Royal Astronomical Society, been able to apply spectroscopic analysis to this object.

M. Faye having called in question Mr. Stone's title to the merit of being the first to exhibit the cause of the errors which had resulted from Encke's treatment of the transit observations in 1769, Mr. Stone has put forward a masterly defence of his position. If any doubts could have remained of the imperfectness of M. Powalky's treatment of the subject—which M. Faye has undertaken to defend—Mr. Stone's paper would have conclusively removed them. He shows that M. Powalky has followed no settled rule in interpreting observations, that he has rejected good observations without any cause, and some observations for no other reason than their incompatibility with the general run of the discussion. Mr. Stone particularly cites the ten available observations of duration. All of these are used by him, and perfectly represented in his result; whereas M. Powalky has fully employed only four, to three of which, taken in combination, he has given the weight of one only. The whole paper is not only most interesting and valuable, but satisfactory as fully establishing the claim of our distinguished fellow-countryman to the honour of having removed what had long been looked upon as a stain on "the most exact of the sciences." If there is any objection to be made against Mr. Stone's defence of his case, it is that here and there it seems to be in the slightest degree too personal. In scientific discussions as in scientific observations, "personality" should be reduced to a minimum. It is, however, not to be wondered at that Mr. Stone should object to remarks which seemed calculated to diminish the value of his researches on the transit-observations of 1769.

For the next few months Saturn will be an interesting object of observation. His rings are now nearly at their widest expansion, and will doubtless be carefully examined by astronomers for any signs of those processes of change which are suspected to be in progress. Towards the end of the quarter Jupiter will also be well

situated for observation. Venus and Mars will be evening stars throughout the quarter, but the latter is getting too far off for effective observation.

Proceedings of the Astronomical Society.

Mr. De la Rue had called attention to the great changes which appeared to have taken place in the figure of a great solar prominence visible during the total eclipse of August, 1868. These changes appeared to suggest that the prominence had undergone an axial rotation during the period occupied by the moon's shadow in travelling from Aden to Guntoor. It now appears, however, that the engraving of the Aden photograph in the 'Engineer,' on the accuracy of which Mr. De la Rue had founded his opinion, was incorrectly designed. Mr. De la Rue has obtained a copy of the original photograph, and he finds that the hypothesis of a marked change having taken place must be abandoned. Instead of the Great Horn being so curved that its point was directed in the opposite direction from that in which it was turned when seen at Guntoor, the aspect of the prominence in the two pictures is almost identical. It requires actual measurement to distinguish any change of position. Mr. De la Rue considers, however, that the evidence is sufficiently distinct to enable us to conclude that some change had occurred in the direction of the great prominence during the forty minutes which elapsed between the Aden and Guntoor observations; but it is impossible to say whether this was due to an axial rotation of the prominences.

In a paper on the late transit of Mercury, by Mr. Abbott, there occur some remarks about the geographical position of Australian towns, which are interesting in connection with the approaching transit of Venus. The longitude of Hobart Town appears to have been well determined, but not with such accuracy as will be required for the application of Delisle's method to the determination of the solar parallax. Captain Kay agrees with the Astronomer Royal in considering that the Australian colonies are unsuited for observing the transit of Venus until better known. Mr. Ellery, on the other hand, thinks differently, and considers that the position of the Melbourne Observatory is as well known as that of the Cape of Good Hope Observatory.

A paper by Mr. Mann on the subject of the same transit contains an elaborate discussion of the observations which were made at the Cape of Good Hope, and cannot fail to be highly valuable to astronomers who may in future times undertake the formation of new tables of Mercury. It will be remembered that in England the whole transit of Mercury was not visible. Mr. Mann was able to employ observations made by Sir T. and Mr. G. Maclear from the

passage of Mercury's centre across the sun's limb at ingress until exterior contact at egress. The result of the examination of twenty-two observations is as follows:—

Correction to excess of Sun's R.A. over Mercury's $= -0''\cdot92 - \cdot092\ \tau$;
" " N.P.D. " $= -0''\cdot16 - \cdot043\ \tau$;

where τ is the assumed error in the determination of the longitude of the Cape of Good Hope Observatory. The observations were made with the $8\frac{1}{2}$-foot equatorial. Sir T. Maclear adds some remarks on the observed diameter of Mercury. He deduces from all the observations the value $8''\cdot376$, with a probable error of $\pm 0''\cdot11$. This result is less than the tabular diameter by $1''\cdot50$. As the apparent diameter of Mercury is increased through the effects of irradiation when the planet is observed off the disc of the sun, and diminished through the same cause when the planet is in transit, the difference is readily explicable.

The Astronomer Royal comments on M. Puiseux's statement that Halley's method can be applied with advantage to the transit of 1874. He interprets M. Puiseux's carefully-worded statement to signify that in the French mathematician's opinion Halley's method is better than Delisle's. We do not find in M. Puiseux's paper any passage which can be so understood. All that Puiseux has said is in one place that the message can be applied "advantageously," and in another that "there can be no reason why it should not be applied." It would be to exaggerate the requirements of courtesy in scientific discussion to assume that M. Puiseux had really another meaning, but was prevented by courtesy from expressing it. Nor will his figures bear such an interpretation. He points to statistics which give intervals somewhat greater than those which come out by Delisle's method; but so skilful a mathematician could not but be aware that Halley's mode involves four observations of contact, Delisle's only two; and that consequently more had to be considered in forming a comparison between their relative advantages than the mere length of the intervals involved. The careful perusal of M. Puiseux's pamphlet suggests the impression that what he really had in his mind in indicating a difference of opinion with the Astronomer Royal was the latter's statement that Halley's method "fails totally" in 1874. The concluding sentence of Mr. Airy's note indicates a change of opinion on this point. After expressing his wish that Halley's method may be applied to the transit as well as Delisle's, he adds, "Every series of observations which can really be brought to bear upon this important determination will be valuable."

Mr. Stone supplies an interesting paper on a "personality" in the determination of the line of collimation of a transit instrument. The existence of a personal error of this sort to an appreciable

amount would be difficult to deal with, and would cast a certain amount of doubt over the whole of the instrumental corrections. By comparing together the observations made at Greenwich by Messrs. Dunkin, Ellis, Creswick, and J. Carpenter, Mr. Stone has discovered that a real personality exists, but it is so small, that, as far as Greenwich observations are concerned, the uncertainties introduced into collimation-determinations may be neglected as insignificant.

Mr. Browning describes a remarkable train of sun-spots, visible on the 7th of March. He attempted to observe them with the full aperture of his fine 12-inch silvered-glass reflector, but the definition was so bad, owing to the state of the atmosphere, that he had to reduce the aperture to 6 inches. He then introduced what is called a solar plane, that is, a plate of parallel glass silvered on the exposed side, into the mouth of the telescope. The spots thus observed presented the appearance of an almost continuous penumbra, in an irregular hollow curved line, with umbræ at intervals; some of the umbræ containing blacker nuclei. On the convex side a portion of the penumbræ assumed the form of a pair of compasses. He found the outside dimensions of the cluster to be from E. to W. 97,700 miles, and from N. to S. 27,130 miles. The group was the largest which had appeared during the recent outbreak. The direction of its length was almost exactly parallel to the sun's equator. A remarkable circumstance attended the approach of the spots to the edge of the sun's disc; the faculous matter around the spots became gradually brighter and brighter, until, when the spots had reached the limb, it quite obliterated the penumbra. The black spots were then seen surrounded by a white border; a distinct proof, if any were needed, that the faculæ are above the solar surface.

Mr. Browning also describes an improved method of mounting finders. Every observer is aware of the inconveniences which result from the imperfect plans at present used for adjusting finders. Mr. Browning proposes a remarkably promising plan, so simple in its details, that the wonder is it has never been used before. In place of the two rings, each with three adjustment-screws, the only arrangement hitherto applied to a movable finder, Mr. Browning has the finder attached to two uprights. Its attachment to the one nearest the eye-piece is so arranged that the finder can be shifted round a horizontal axis perpendicular to the axis of the telescope; the attachment to the other permits of motion round a vertical axis (the telescope being understood, for the purposes of this description, to be placed in a horizontal position). It is the more necessary that a simple mode of adjusting finders should be made use of, because in spectroscopic observations the star or other object under examination must be brought exactly

between the jaws of the spectroscopic-slit, or the spectrum will not be visible.

Mr. Proctor supplies the elements of his recalculation of the rotation of Mars. The total period taken into account contains 640,284,123 seconds, corresponding to 72,232 rotations of the planet, and giving a rotation-period of 24 h. 37 m. 22·736 s. He remarks that Kaiser's period (24 h. 37 m. 22·625 s.) would throw the Kaiser sea so far from the centre of the disc at the epoch of Hooke's observation, that that feature would have been concealed from view by the haze which always hides the planet's line. Hooke's picture shows the Kaiser sea only 18° from the centre of the disc. On the other hand, Kaiser's estimate, hitherto undoubtedly the most exact, suffices to show that it *was* the Kaiser sea, and not the somewhat similar Dawes' strait, that Hooke saw; for the latter, according to Kaiser's period, must have been on the farther side of the planet at the time of Hooke's observation. The peri d given by MM. Beer and Mädler (24 h. 37 m. 23·8 s.), on the other hand, although accounting for Hooke's observation on the omission of a complete rotation, is shown by Sir W. Herschel's drawings to be incorrect. It is a matter of some interest thus to be able to assign the exact period of a planet's rotation. As our earth's motion of rotation is slowly diminishing through the moon's action, it may be important, at some far distant epoch, to have in Mars a cosmical clock of undoubted accuracy. For the comparative smallness of Mars, his greater distance from the sun, the smaller proportion which the seas on his surface bear to the continents, and the fact that he has no satellite, all encourage the belief that his period of rotation cannot be affected appreciably by the motion of a tidal wave, as is the case with the earth.

A paper by Mr. Maclear on the subject of the Meteoric shower of November, 1868, is chiefly remarkable for the evidence it supplies of the wide range over which the display of last November was to be seen. We have already had accounts of the shower as seen in America; it was well seen in England; and it now appears that it was seen under favourable circumstances at the Cape of Good Hope. This suffices to show that the part of the meteor system traversed last November differs wholly in character from that which gave birth to the more brilliant, but much more short-lived display of November, 1866.

Professor Cayley gives a simple proof of the property, that if an indefinitely thin shell of uniform density, rounded by two similar and similarly situated ellipsoids, attract a point P on its outer surface, the attraction (assumed to act in the direction of the normal) is equal to twice the attraction of an infinite plate, the thickness of which is equal to the normal thickness of the shell at the point P. The proof may be thus summarized:—

Let a cone, having its vertex at P, circumscribe the interior ellipsoid. All the mass of the shell outside this cone may be neglected when the shell is supposed indefinitely thin. Of the part within, it will be obvious, on consideration, that the two portions separated by the circle in which the cone and the inner ellipsoid touch each other, attract P equally. The portion nearer to P may be divided into two, by a plane touching the inner ellipsoid, when the normal through P meets it, and of these parts only the one next to P need be considered, the attraction of the other vanishing in respect to that of this part. Thus, finally, we get the attraction on P equal to twice that of a cone having P as vertex, and inscribed within the shell, so that its base touches the inner ellipsoid. In the limit, the vertical angle of this cone becomes equal to two right angles, and the attraction of the cone becomes that of an infinite plane, whose thickness is equal to the normal thickness of the shell at P.

The same eminent mathematician gives a remarkably simple explanation of Gauss's solution of the problem of determining a planet's orbit, from three observations. We must refer those of our readers who are interested in this problem (selected by the Cambridge University as the subject of the Adams' Prize Essay), to the paper itself, as it would be wholly impossible either to abbreviate Professor Cayley's treatment of the question or to give the whole of it in these pages.

Mr. Dunkin gives another of those interesting papers on personality in observation, which have recently been founded by the Greenwich observers on the immense amount of valuable material available to them for the purpose. The object of the present paper is a personality in observing transits of the moon's limb. It has been described by the Astronomer Royal as, strictly speaking, a difference between the personal equation for the moon and that for the stars; the duration of the impression on the nerves of the eye not being the same when the moon is observed as when a star is. The effect of the personality is visible more in the tabular errors in the first half of the lunation than in the second, but the differences of each observer's mean from the mean of all are too small to enable one to trace the personality to any particular source. An important result of the investigation is the evidence it affords of the necessity of intermixing observers, when absolute places have to be determined.

Mr. Kincaid describes a driving-clock founded on hydraulic principles. The contrivance would need trial, we should imagine, before its actual qualities can be pronounced upon. Theoretically it is excellent.

4. BOTANY—VEGETABLE PHYSIOLOGY AND MORPHOLOGY; AND RECENT LITERATURE.

Aster salignus.—We some time since noted the discovery of this plant by Mr. Hiern, of St. John's College, near Cambridge. Two ladies—Miss Bever and Miss Edmonds—announce its occurrence on the shores of Derwentwater. Besides in Cambridge, this plant also occurs in several places on the banks of the Tay, between Dalguise and Seggieden. In one locality below Perth, Dr. White remarks that it is associated with several introduced plants, such as *Linaria repens*, *Petasites alba*, *Sanguisorba Canadensis*, *Mimulus luteus*, *Crocus vernus*, and *Narcissus pseudo-narcissus*, which are all common, more or less, and established along the banks of the river. In France, *Aster novi Belgii* seems to hold the same place as *A. salignus* does in Britain—that of an exotic plant, well established on the banks of several rivers, as near Strasbourg, Langres, and Lyons.

A Method of Bleaching Wood Pulp.—M. Ouvli, a French chemist, states that chloride of lime is open to this objection in the process of pulp-bleaching for the purposes of paper manufactories, *viz.* that if at all in excess, it gives a yellow colour to the pulp. Powerful acids also, without exception, tend to give a reddish tinge to the paper when exposed for a long time to the action of sun or moisture (whence the colour of many foreign papers in books), and the least trace of iron is sufficient in a very short time to blacken the pulp. M. Ouvli says he has succeeded in avoiding all these inconveniences by the use of the following mixture. For a hundred-weight of wood-pulp, 400 grammes ($\frac{4}{5}$ths of a pound) of oxalic acid are taken; this has the double advantage of bleaching the colouring matter already oxidized, and of neutralizing the alkaline principles which favour such oxidation. To the oxalic acid one pound or a little more of sulphate of alumina is added, entirely deprived of iron. The principal agent in this mode of bleaching is the oxalic acid, the power of which over vegetable colouring matters is well known. The alum has no bleaching power of its own, but forms with the colouring matter of the wood an almost colourless "lake," which has the effect of increasing the brilliancy of the pulp.

Curvature in Plants.—M. Ed. Prillieux has studied this subject in a very detailed manner—experiments both on plants and on imitative models having been extensively made. He arrives at the conclusion that a purely mechanical cause must be attributed to the curvature produced by shocks and vibrations on buds, contrary to general opinion, which had considered these phenomena as of a very different character and peculiar to living beings (whereas

M. Prillieux produced the same results in a model). A certain state of the tissues is indispensable to their manifestation; they can only be produced at that period of development when the tissues are sufficiently flexible; but it is, nevertheless, undeniably true that they are due to a physical cause.

The Sleep of Plants.—In an exhaustive essay on this curious subject, of much physiological importance, M. Royer reviews the opinions of those who have written on the question, and adduces a great number of facts in illustration of the various causes which produce the sleep of leaves and of flowers. These, he maintains, are not quite identical. He distinguishes a diurnal sleep as well as a nocturnal for plants equally with animals. Heat, light, and turgescence, are influential in affecting the sleep of leaves—only heat and turgescence in the sleep of the corolla—by their excess or diminution. Flowers when they sleep assume the form of their characteristic æstivation, just as many animals assume the position they occupied *in utero*. The inclination of flowers to the sun depends on the peduncle, not on the flower at all.

Excretion of Carbonic Acid by Plants.—Mr. Broughton, Chemist to the Cinchona Plantations of the Madras Government, has made, with a Sprengel's air-pump, some important observations as to the exhalation of CO_2 by plants—a phenomenon which was well known to occur in the night. The experiments were made mostly on cut portions of the plants, but experiments were also made for control on plants as they actually grow. Sometimes the deprivation of oxygen was effected by substituting for air an atmosphere of hydrogen or nitrogen; whilst comparative experiments were made on plants supplied with air that had been freed from carbonic acid. The main conclusions to which he was led are enunciated by the author as follows: *—

1st. That nearly all parts of growing plants evolve carbonic acid in considerable quantities, quite independent of direct oxidation.

2nd. That this evolution is connected with the life of the plant.

3rd. That it is due to two causes, namely, to previous oxidation, resulting, after a lapse of time, in the production of carbonic acid, and to the separation of carbonic acid from the proximate principles of the plant while undergoing the chemical changes incident to plant-growth.

The Respiration of Aquatic Plants in Darkness.—M. Deherain has pointed out that when aquatic plants are kept in darkness they are literally asphyxiated; for on making examination of the water in which they have died, he has found absolutely no trace of oxygen, but only carbonic acid and nitrogen. In a pond where a very dense

* 'Proceedings Royal Society,' April 29th.

growth of *Lemna minor* had been allowed to accumulate on the surface, a sudden death of all the fish in the water occurred, and the smell of sulphuretted hydrogen was remarkably strong. On making examination of the water by careful chemical analysis, M. Dehe-rain found that there was absolutely no dissolved oxygen present, hence the death of the fish. The aquatic plants had been killed by the exclusion of light caused by the Lemna growth, and they had absorbed what oxygen was available. M. Van Tieghem, a very distinguished French botanist, relates some interesting experiments on the action of light in the respiration of aquatic plants. He maintains that the chlorophyl is brought into a condition comparable to that of a *phosphorescent* body by the action of direct sunlight. It is direct sunlight only which is competent to *start* the decomposition of carbonic acid by the chlorophyl—as numerous experiments prove,—diffused (polarized) sunlight not having that power: when withdrawn from direct sunlight and kept in the dark, Van Tieghem observed that the plant still continued to exert chemical action for *three* hours, and for *nine* hours if kept in diffused daylight instead of darkness. From this he concludes that the vibrations induced by the chemical rays of sunlight are continued in the chlorophyl after removal from their contact, which is indicated by the continued chemical action, just as light is continued by the sulphides of barium, &c.; and he supposes that diffused daylight, though incompetent to *start* this action, can assist in continuing it.

The Action of the Cuticle in the Respiration of Plants.—M. Barthélemy has applied the results of Graham's researches on dialysis of gases through colloid membranes to the case of plant-respiration. In plants there exists a cuticle which has a chemical composition and a physical constitution like caoutchouc. It is wanting at the "stomata" which occur on the under-surface of leaves. The experiments of many observers, notably Boussingault, have shown that the exhalation of oxygen is greatest when sunlight falls on the *upper* surface of leaves. M. Barthélemy explains this by supposing the respiration to take place *through* the cuticle, the stomata perhaps absorbing nitrogen. The relative permeability of caoutchouc to various gases agrees well with the hypothesis—carbonic acid passing most freely, oxygen also freely, and nitrogen with difficulty. This view is further supported by ingenious experiments, in which *leaves* were substituted for caoutchouc in experiments similar to Mr. Graham's, and very fairly concordant results were attained.

Cephalodia of Lichens.—Dr. Nylander makes some important observations on these organs, which were but little known before he pointed out their importance as furnishing a primary anatomical character in their gonimia. They occur only in thalli which have

gonidia. He distinguishes three principal kinds:—1. Epigenous, which are the most frequent; 2. Hypogenous, known only in *Peltidea* and *Psoroma*; 3. Endogenous, or Pyrenoid, which occur in foliaceous lichens. Recently Dr. Nylander has detected both epigenous and hypogenous cephalodia in *Lecanora araneosa* from New Zealand.

Mr. Lauder Lindsay treats of a very interesting matter relating to Lichens—*viz.* those species parasitic on other lichens—in the 'Quarterly Journal of Microscopical Science.'

A New Mode of Preserving Fungi.—Mr. James English has hit on a very effective method of preparing Fungi for the herbarium, and has communicated a paper on the subject to the Botanical Society of Edinburgh. By *waxing* the specimens which it is desired to preserve, the natural pileus and stipe are retained. Specimens treated in this manner in 1866 are now as fresh as when first prepared, and a series of fungi, treated in this manner by Mr. English, are now in the Museum of the Botanical Society of Edinburgh.

New Diatoms from the Arran Islands, Galway.—The Rev. Eugene O'Meara describes and figures in the 'Quarterly Journal of Microscopical Science' more new Diatoms from dredgings off the west coast of Ireland. The species are:—*Pleurosigma giganteum*, var. *baccatum*, *Plagiogramma costatum*, *Melosira Wrightii*, *Pinnularia marginata*, *Pinnularia scutellum*, and *Amphiprora costata.*

Botanical Appointment.—Dr. Henry Trimen, of King's College, London, Lecturer on Botany at St. Mary's Hospital Medical School, has been appointed an assistant in the Botanical Department of the British Museum. Those who know the vast accumulation of unworked material at the Museum will rejoice that an additional office has been created, and that so able a gentleman as Dr. Trimen has been chosen to fill it.

5. CHEMISTRY.

At the soirée of the Royal Society, on March 6th, Mr. H. C. Sorby, F.R.S., exhibited for the first time some phenomena in his spectrum microscope, which have led him to the conclusion that they are due to the presence of a new element, for which he has proposed the name of jargonium.

Mr. Sorby describes jargonia as being an earth closely allied to zirconia, existing in small quantity in zircons from various localities, but constituting the chief ingredient of some of the jargons from Ceylon. It is, however, distinguished from zirconia and all other known elementary substances by the following very remarkable

properties. The natural silicate is almost, if not quite, colourless, and yet it gives a spectrum which shows above a dozen narrow black lines, much more distinct than even those characteristic of salts of didymium. When melted with borax it gives a glassy bead, clear and colourless both hot and cold, and no trace of absorption bands can be seen in the spectrum; but if the borax bead be saturated at a high temperature, and flamed so that it may be filled with crystals of borate of jargonia, the spectrum shows four distinct absorption bands, unlike those due to any other known substance. Further researches have shown Mr. Sorby that jargonia exists in two distinct conditions, which have different specific gravities and optical properties. The flamed borax beads give two entirely different spectra, according to the temperature to which the enclosed crystals have been exposed, and there is an analogous difference in the silicates. On taking a pale-green jargon, which naturally showed a mere faint trace of the absorption bands, and keeping it at a bright red heat for some time, the specific gravity gradually increased from 4·20 to 4·52, and the spectrum then showed all the narrow black absorption bands in great perfection. It appears, however, that Professor A. H. Church, M.A., published a similar discovery nearly three years ago in the 'Intellectual Observer.' Not only did he describe bands, but he noticed their occurrence in the spectra of some stones from particular localities, and their absence from stones from other localities. He also added his views as to the cause of these bands—the presence of an element in some specimens, not found in others. An account of Mr. Sorby's further discoveries in spectrum and microscopic analysis will be found elsewhere.

During an examination of the Heaton process for making steel at Langley Mill, Mr. Crookes has noticed a remarkable instance of the crystallization of iron. When the violence of the action between the molten iron and the nitrate of soda has subsided, the lower portion of the apparatus, called the converter, is detached, and after a few minutes the contents are turned out on to the floor in the form of a porous mass of nearly $\frac{3}{4}$ of a ton in weight. Upon examining portions of this metallic sponge, it is found to consist of a segregation of minute feathery crystals of iron, apparently built up of small cubes. The outlines of some of these are perfectly sharp, and their appearance, especially in the cavities, is very beautiful.

In February, 1868, two Belgian chemists—MM. Graebe and Liebermann—communicated a memoir on alizarine, from which an intimate relation was acknowledged between this colouring matter and anthracene. By heating alizarine with zinc dust, they obtained as the sole product of reduction a hydrocarbon having all the qualities of anthracene. Having thus obtained anthracene as

a product of alizarine, MM. Graebe and Liebermann have since succeeded in solving the inverse problem, that is to say, the artificial preparation of alizarine by means of anthracene. They convert that hydrocarbon into alcohol, and the alcohol into an acid (lizaric acid and alizarine being synonymous), by acting upon the hydrocarbon with chlorine or bromine, and next effecting a double decomposition by means of acetate of potassa and caustic potassa; after which an oxidizing agent is again made to act upon the alcohol so obtained. The properties of the product, as well as the colours which it has given on mordaunted cotton, prove the complete identity of artificial alizarine with that from madder root.

Professor G. Hinrichs has described the following ingenious way of preserving sodium untarnished as a lecture specimen.—Take two test-tubes, one a little smaller than the other, so as to slip into the latter without leaving much space between the two glass walls; put some carefully-cleaned sodium in the wider tube, insert the more narrow tube, having previously given a thin coating of beeswax to the upper part of this latter, then gently heat the whole on a sand-bath. The sodium will fuse, and by a gentle pressure, the inner tube is pressed down, so as to force the fused metal over a large surface between the two tubes, while the air is totally excluded by the beeswax. Sodium has been kept for more than six months in this way as bright and brilliant as when first put up.

It is well known that hydrochloric acid is used for the purposes of dissolving the earthy salts of bones, in order to obtain the gelatine they contain in such a state as to render that substance readily soluble in boiling water. The use, however, of hydrochloric acid is rendered rather inconvenient for this purpose, on account of the formation of chloride of calcium, which interferes with the drying of the gelatine. M. Coignet, at Paris, has found that sulphurous acid answers the purpose of hydrochloric acid in this instance perfectly well. The bones are placed in cold water, and through the water a current of sulphurous acid gas is forced, so long as is required to completely soften the bones, which are afterwards washed in fresh water wherein some sulphurous acid gas has been previously dissolved.

Professor Horsford, of Yale College, has tried to detect fluorine in the human brain; he was induced to do so by the fact that fluorine so frequently accompanies phosphoric acid in the mineral kingdom, and also on account of the large proportion of phosphoric acid found in the brain and nerves by Von Bibra and others. After having very carefully ascertained that the reagents he was about to apply were quite free from fluorine, the learned professor operated upon a human brain which had been long kept in spirits of wine,

but which in consequence of neglect had, by the evaporation of the liquor, become wrinkled up and dry. As a result of a series of carefully-made experiments, he has proved undoubtedly the existence of fluorine in the brain.

From some experiments made by Professor Bloxam, of King's College, it appears that a mixture of tincture of guaiacum and ozonized ether (that is to say, a solution of peroxide of hydrogen in ether) instantly produces, with blood or bloodstains, a beautiful blue tint. Professor Bloxam mentioned that in the case of a bloodstain twenty years old, he had extracted a single linen fibre with an almost inappreciable amount of stain on it; and had found the characteristic blue colour was immediately induced by the test, and readily detected by microscopical examination.

It is a well-known fact that iron is dissolved by molten zinc, but nowhere is any definite alloy of these metals described, nor yet is it stated how much iron is dissolved by zinc. Dr. Oudemans, jun., obtained for analysis a piece of alloy which had been formed in an iron vessel wherein zinc had been fused for several weeks continuously; this alloy was found deposited at the bottom of the vessel, and became an impediment to the melting operations, in consequence of its relative infusibility. In its physical aspect the alloy was of very much whiter colour, and crystalline structure entirely different from zinc; the alloy dissolved very readily and briskly in dilute sulphuric or hydrochloric acid, and was found, on analysis, to contain 4·6 per cent. of iron.

M. Zschiesche has prepared sulphate of lanthanium of such a purity that a thickness of 17 centimetres of a saturated solution gave no trace of the absorption bands of didymium. Working on this, he has found the atomic weight of lanthanium to be, from a mean of six experiments, 45·09. The extremes were 44·72 and 45·625.

M. E. Ludwig has come to the conclusion, as a consequence of a series of determinations of the specific gravity of chlorine gas, that this gas belongs to those vapours which only obey Mariotte's law when it is at a temperature rather remote from that at which it is condensed to the fluid state. The specific gravity of chlorine at 20° C. is 2·4807; at 50° C., 2·4783; at 100°, 2·4685; at 150°, 2·4609; at 200°, 2·4502. According to experiments made by Stas, the specific gravity of chlorine, deduced from its atomic weight, is 2·45012.

In order to obtain a platinizing fluid capable of platinizing copper, yellow metal, and brass, add, to a moderately-concentrated solution of chloride of platinum, finely-powdered carbonate of soda until effervescence ceases, next some glucose, and afterwards just

so much common salt as will cause a whitish-coloured precipitate. When it is desired to apply this mixture for platinizing, the objects to be treated are placed in a vessel made of zinc and perforated with holes; the vessel is then placed, with its contents, for a few seconds in the mixture just described, which, just previous to using, should be heated to 60° C. On being removed from the zinc vessel, the objects are to be washed with water and dried in saw-dust.

Professor Nicklès calls attention to the fact, that when chloride of sulphur of commerce is mixed with sulphide of carbon wherein phosphorus has been previously dissolved, a fluid is formed, which, though emitting fumes when in contact with air, is harmless, and may be for any length of time kept in well-stoppered bottles; on addition of liquid ammonia, however, or on passing into this liquid a few bubbles of ammonia gas, a most intense combustion at once ensues. This is due to the fact that the ammonia seizes upon the chloride of sulphur, forming chloride of ammonium, whereby so much heat is set free as to cause the combustion of the sulphide of carbon and phosphorus dissolved in it.

Proceedings of the Chemical Society.

On Thursday, March 4, 1869, Mr. Tomlinson read his long-promised lecture "On Catharism, or the Influence of Chemically Clean Surfaces." He explained the sense in which he applied the new term, catharism (from καθαρος, *pure* or *clean*), distinguishing between "clean" in its ordinary and in its chemical sense. The finger could not be made chemically clean by any process, whereas a glass rod, cleansed with strong acids or alkalies, and well washed, was chemically clean, and no longer possessed the power of liberating either salt or vapour from liquids. The action of solid bodies in determining these changes he ascribes to the greasy film which, after exposure to the air, they are sure to acquire. For this film, the adhesion of the solid or vapour is greater than it is for the glass, and hence the effect of the solid. To such chemical uncleanness all phenomena of this kind should, he thinks, be ascribed; and he defines a nucleus as a body which "has a stronger adhesion for the gas, or the salt or the vapour of a solution, than for the liquid which holds it in solution." He repudiates the notion that temperature has anything to do with the phenomena of supersaturation, and describes experiments in which supersaturated solutions of various salts were kept for hours in catharized vessels at a temperature of 10° Fahr. without crystallization taking place. This was even observed with alum, which does not usually exhibit this peculiarity. The views of Löwel on crystallization and the phenomena

of *soubresaut*, or bumping, during ebullition, were next discussed, and a variety of interesting facts were described. The action of porous bodies in assisting distillation was explained by their absorption of the vapour of the boiling liquids, which was subsequently given out in never-ceasing jets; and a number of obscure phenomena in chemistry—such as the passive condition of iron, and the slight action of sulphuric acid on pure and amalgamated zinc—were explained by the doctrine of catharism, for which the lecturer claimed the properties of a principle of nature—*viz.* generality and breadth of application—a principle which was as yet new to science.

At the meeting on March 18, 1869, a paper was read by Mr. Arthur Elliott, "On the Determination of Carbon in Cast Iron." The author's method consists in treating pulverized iron borings with solution of sulphate of copper, heating gently for ten minutes, when the iron dissolves, and metallic copper separates, the carbon remaining undissolved. Acid solution of chloride of copper is then added, and the mixture heated nearly to the boiling point, until the separated copper dissolves. The carbon is collected on a filter made of combustion tube, and stopped first with broken glass, and then loosely with ignited asbestos, and washed with boiling water till free from chlorides. It is then converted into carbonic acid, and the latter determined by oxidation with chromic acid.

A paper was then read by Professor G. G. Stokes, F.R.S., "On a Certain Reaction of Quinine." The reaction is best observed by diffused daylight entering a darkened room through a hole in the shutter of about 4 or 5 inches square, or a packing-case may be made to answer very well. The hole is covered with glass coloured a deep violet by manganese. In front of it is placed a white porcelain tablet; a solution of quinine in very weak alcohol, or very small fragments may be used. In some cases alcohol interferes with the reaction. The phenomena exhibited by sulphuric and hydrochloric acids were as follows:—When a drop of the quinine solution was touched by a rod dipped in dilute sulphuric acid, the fluorescence of the quinine was instantly developed. With hydrochloric acid no apparent effect was produced, but hydrochloric acid destroyed the effect of sulphuric acid; and if a little sulphuric acid were added to the drop containing only hydrochloric acid. no effect was manifest. The author found that, on trying a variety of acids, they ranged definitely into two classes, A and B—class A developing fluorescence like sulphuric acid, and class B destroying it, like hydrochloric acid. The classification made by the quinine reaction agrees almost exactly with the old distinction of ox-acids and hydracids. The author had found, however, that hyposulphurous acid, which is not usually ranked with the hydracids, ranged itself in

class B, and led him to seek for other analogies between hyposulphurous and the hydracids; and he found that hyposulphite of soda restored the blue colour to litmus which had been reddened with chloride of mercury; he also found that, in common with the hydracids, it very readily decomposed cyanide of mercury. Mr. E. T. Chapman next read an abstract of a paper by himself and Mr. Miles H. Smith, "On the Butylic Compounds derived from Alcohol by Fermentation." The authors had operated on about 17 gallons of London fusel-oil. After subjecting it to a series of fractional distillations they obtained a body consisting of butylic alcohol, contaminated with small quantities of iso-butylic alcohol. From this butylic alcohol the authors prepared the iodide, bromide, nitrate, acetate, and nitrate of butyl, from which the iso-butyl compounds are separated by fractional distillation.

The anniversary meeting of the Chemical Society was held on Tuesday, March 30th, 1869, when the council and officers for the ensuing year were elected. The new President was A. W. Williamson, Ph.D., F.R.S.

At the next meeting, Thursday, April 1st, 1859, a paper, by Messrs. E. T. Chapman and Miles H. Smith, "On some Decompositions of the Acids of the Acetic Series," was read. Mr. W. H. Perkin, F.R.S., then made some remarks in reference to a paper published in the 'Chemical News,' by Fittig, "On the Constitution of Coumarin and Coumaric Acid." These papers only being of scientific interest need not be further alluded to here.

At the meeting on Thursday, April 15th, 1869, Mr. Chapman read a paper by himself and Mr. M. H. Smith, "On Propyl Compounds derived from the Propylic Alcohol of Fermentation." They operated on that portion of fusel-oil which remained after the amylic, butylic, and ethylic alcohols had been as perfectly as possible removed. Propyl alcohol is a colourless liquid of strong but not oppressive odour; it boils at 97° C., and its sp. gr. is 1·8120 at 16° C. On oxidation it yields propionic acid. Mr. Chapman then read a note "On Bromide of Amyl," by himself and Mr. M. H. Smith. They find that it is a mobile liquid, boiling at 121° C., and of sp. gr. 1·2173 at 16° C. They drew attention to the fact that the intervals between the boiling points of the bromides of methyl, ethyl, and propyl, are constant, *viz.* about 29° C.; that between bromide of propyl and bromide of butyl is only 22°, but that the interval between the bromides of butyl and amyl is again 29°. Professor Wanklyn then made a verbal communication touching the atomicity of sodium. He considered, from researches which had occupied him during some months, that sodium was an eminently polyvalent element.

At the meeting of the Chemical Society, on May 6th, 1869, it

was agreed that the following petition should be presented to both Houses of Parliament:—

The Humble Petition of the President and Council of the Chemical Society.

Sheweth—That the Chemical Society was incorporated by Royal Charter for the general advancement of Chemical Science, as intimately connected with the prosperity of the manufactures of the United Kingdom. That in the opinion of your petitioners, the future intellectual position of Great Britain and her success as a manufacturing nation, are in a great measure dependent on the scientific education of her people. That the Society of Arts, in their report on technical education, assert that the only effectual systematic training for technical pursuits, consists of two steps—first, a thorough study of several branches of science, including chemistry; secondly, professional pupillage. That at the present time the study of natural science is altogether neglected in a large number of our secondary schools, while in the remainder it occupies only a subordinate position, both in respect of the time allotted to it and of the credit to be gained by proficiency in it. That the neglect of the study of natural science is in great part due to the influence exercised by the endowed schools, which by their number, their antiquity, and the large funds at their disposal, determine the course of studies in other schools, their own course of education representing the requirements of a past, rather than of the present age. That the necessity for inquiry into the teaching in endowed grammar-schools has already been recognized, by the appointment by Her Majesty of three commissions to report on this class of schools in England and Scotland. That the Schools Inquiry Commission have in their report pointed out various practicable means for the promotion and extension of the study of physical science in schools. Your petitioners, therefore, humbly pray your Honourable House to enact such laws as may procure for Chemistry, and other branches of natural science, as important a position among endowed school studies as that now occupied by Latin and Greek. And your petitioners will, &c.

Mr. J. Lothian Bell then delivered a lecture "On the Chemistry of the Blast-furnace." It is impossible to do more than refer to this exhaustive paper, in which every part of the operations going forward in the blast-furnace were passed in review, and the chemical actions going on explained. After the delivery of this lecture, a discussion followed, in which Mr. Siemens, Captain Noble, Mr. Crossley, Mr. Cochrane, and others took part. After Mr. Bell's lecture, Mr. W. Chandler Roberts gave a verbal account of, and exhibited the apparatus for showing the expansion of palladium by

hydrogenium. It consisted of a coil formed with a strip of palladium and a strip of platinum, each being 300mm. long, 3mm. wide, and 0·3mm. thick. This is put into a glass vessel filled with acidulated water; a plate or wire of platinum is placed near it, and the ribbon or wire connected with either pole of a battery by means of a commutator. The coil is first connected with the zinc pole of the battery, hydrogen is then thrown on the surface of the metal, which consumes the previously occluded hydrogen, and causes the index to move rapidly back to zero.

6. ENGINEERING—CIVIL AND MECHANICAL.

(Proceedings of Societies and recent Publications.)

In order to accommodate the increasing demand for facilities of transport fostered by the continued extension of our railways, lines of communication are now demanded in directions where, until recently, they were never thought of, and the passage of rivers—and other obstacles, which, in the early days of engineering, would have been carefully avoided—is now boldly effected as a matter of course. It is perhaps difficult to say exactly to what length of span a bridge may be built, but for practical purposes it is found that the largest spans are most easily obtainable with bridges constructed on the suspension principle. Coupling this fact with the recognized want of improved means of communication between this country and the Continent, M. Boutet has put forward a scheme for erecting a bridge across the channel from the Shakspeare Cliff, Dover, to Cape Blanc Nez, on the opposite coast; it is to consist of ten clear spans, each 3282 yards long (nearly two miles), with a platform 360 feet above the average sea-level. Impossible as we believe the realization of such a work to be, its author has, it is understood, succeeded in recommending his plan to the favourable notice of the Emperor of the French and Earl Granville. Projects have been put forward also for crossing the channel by means of a tunnel or subway, but the great question in connection with such works, and which must ultimately settle the point, is, Will they pay? Supposing it to be clearly demonstrable that they would prove remunerative when completed, is the yearly increasing traffic to be subject to the numerous inconveniences from which it now suffers during the many years such works would be under construction?

Very different, however, to the above schemes is the joint proposal of Messrs. John Fowler, James Abernethy, and William Wilson. According to this plan railway trains would be conveyed

bodily across the channel on huge steam ferry-boats, built for the purpose, and provided with suitable harbour accommodation on either shore. The proposed route is from Dover to Andrecelles, at both of which places there exist facilities for constructing the necessary works. The laying down of a few miles of railway from Andrecelles to Wimereux would ease the journey from Calais to the latter station, and shorten the distance to Paris by fourteen miles. A bill for this "English and Continental Intercommunication" project was deposited last session, but it has, we understand, been postponed till next year for the adjustment of preliminary arrangements and for the further consideration of details.

Proceedings of Societies.

Institution of Civil Engineers.—On the 2nd March last two papers were read on the subject of bridge foundations—one by Mr. Irvine Bell "On Sinking Wells for the Foundations of the Piers of the Bridge over the River Jumna, Delhi Railway," and the other by Mr. John Milroy, entitled "Description of Apparatus for Excavating the Interior of, and for Sinking, Iron Cylinders." In the former paper, the author, after describing the native plans of sinking wells by means of a spade called a "phaora," and, after the first five feet, by an implement called a "jham," proceeded to describe the mode of forming the foundations of the bridge over the Jumna at Sirsawa. In some instances the sites of the piers were got clear of water by diverting the river at different points during the dry season, while in other cases islands were formed by driving a half-circle of piles on the up stream side, then lowering sand-bags on the down stream side, to the height of four or five feet, and afterwards filling up with sand to five feet below low water. The curb was first sunk by men working with the "phaora" and basket, till the upper edge was within three inches of the level of the water, when a ring of brickwork was carried up to a height of six feet. The excavation of the interior was then proceeded with by means of the "jham" and divers in the old native style. Afterwards a further height of ten feet of brickwork was added, but the material was now removed by a sand-pump worked by a steam hoist of 4-horse power.

Mr. Milroy, in his paper, stated that the great desideratum, in cylinder sinking, had hitherto been some method of excavating the earth from the interior, without at the same time having to take out the water, and to keep it out during the operations. This object seemed to the author to have been attained by a machine of his invention, which was used in the construction of the bridge over the river Clyde, for the Glasgow Union Railway, a description of which he then proceeded to give.

A most interesting paper was read on 9th March "On American Locomotives and Railway Stock," by Mr. Zerah Colburn, the discussion on which extended over several evenings. In this a description was given of locomotive engineering in the States, and comparisons were drawn between it and the practice in this country. The paper was, however, too full of statistics and details to admit of a short abstract.

Mr. W. Shelford, in a paper "On the Outfall of the River Humber," described the estuary of that river as the outlet for the fresh waters from a drainage area of 10,500 square miles, or one-fifth of the whole area of England; but the present paper only treated of the outfall, the observations being arranged under four heads, *viz.*—1. The facts in connection with the past and present condition of the outfall, and of its peculiar features. 2. The ascertained alterations in the tidal *régime*. 3. The relative value of tidal and fresh water at the outfall. And 4. The relation of the operations of nature and of engineering works to the facts recorded.

"A Description of the Low-water Basin at Birkenhead," by Mr. J. Ellacott, read on 11th May last, stated that according to plans sanctioned by Parliament in 1844 and 1853 the Low-water Basin was intended chiefly as a deep-water access, and as a sort of refuge for shipping in the Mersey at all states of the tide. The basin is 1750 feet in length, 300 feet in width at the mouth, and 400 feet wide at the extreme end. The area is 14 acres, and the depth 12 feet 4 inches below low-water ordinary spring tides. A description of the piling was given by the author as well as an account of the sluicing arrangements. In 1866 an Act was obtained for converting the Low-water Basin into a wet dock.

Another paper was read at the same meeting by M. Jules Gaudard, of Lausanne, "On the Present State of Knowledge of the Strength and Resistance of Materials." The author stated that the theory of the strength and resistance of materials was closely connected with that of molecular mechanics; he then proceeded to consider the forces of various kinds to which materials were subjected, giving the results and formulæ of the most modern investigations.

Institution of Naval Architects.—The annual meeting of this Institution took place in March last, when several valuable and interesting papers were read. Of those which were of special interest to the engineer may be mentioned the following:—"On the Law of Resistance of Armour Plates," by Mr. William Fairbairn, LL.D., F.R.S.; "On the Stability of Floating Docks," by Mr. George B. Rennie; "Hydraulic Steering Gear," by Captain Inglefield, R.N.; "On Railway Communication across the Sea," by Mr. John Scott Russell, F.R.S.; "On Horse Power," by Mr. J. S.

Holland, R.N.; and on "Strains in Propeller Shafts," by Mr. W. J. Macquorn Rankine, C.E., LL.D., F.R.S.

Association of Engineers, Glasgow.—At a meeting of this Association in April last, the President, Mr. John Page, C.E., read a paper on "Pipes and the Jointing of Gas and Water Mains." In alluding to the enormous waste of gas through leakage, Mr. Page reviewed the different modes of jointing at present in use, and dwelling on the difficulty in making and maintaining good joints under any circumstances, particularly in the curved pipes, he exhibited drawings of a very simple system, and clearly showed that a joint on a curved pipe made in that manner could not move; a joint tested under the most unfavourable circumstances having stood a pressure of 600 lbs. to the square inch.

A paper by Mr. Robert Burn, on "The Machinery used for Cleaning and Packing East India Cotton, and on the Application of the Seeds for Feeding Cattle," also deserves a notice, as dealing with a subject of first importance to India, and to the cotton manufacturers of this country.

Institution of Mechanical Engineers.—At a general meeting of the Institution of Mechanical Engineers, held at Birmingham on 29th April last, a paper was read by Mr. James S. E. Swindell, being a "Description of Guibal's Ventilating Fan employed at the Homer Hill Colliery, Cradley." This fan has eight vanes, and revolves on a horizontal shaft within a cylindrical casing of brick-work. The fan is $16\frac{1}{2}$ feet in diameter, and $4\frac{3}{4}$ feet wide; its usual working speed is twenty-six revolutions per minute, discharging 13,500 cubic feet of air per minute; but it can be got up in one minute's time to ninety-six revolutions, discharging 51,700 cubit feet per minute. This is the first mechanical ventilation that has been applied in the working of the South Staffordshire thick or ten-yard coal. It has now been running about nine months without a single stoppage for repairs. The total cost of the fan, with engine and connections, is only about one-third of that of an ordinary ventilating furnace for producing the same amount of ventilation.

Another paper, by M. E. Gellerat, of Paris, was a "Description of the Steam Road Roller used in Paris." This roller consists of a locomotive engine carried entirely upon two large cast-iron rollers of equal size, which are both driven by the engine, the course of the machine being controlled by a special arrangement for changing the direction of the roller axles. The results of numerous data show that the cost of horse rolling in Paris is about 14*d.* per ton per mile, whereas for steam road rolling the actual payment is only half that amount, or 7*d.* per ton per mile, including the contractor's profit.

Literature.

'A Treaties on Lathes and Turning, Simple, Mechanical, and Ornamental,'* by W. Henry Northcote. This work is calculated to prove a useful addition to the mechanical engineer's library, and will be referred to with interest by both professional men and amateurs. It is divided into four parts. The first part contains a general description of the different kinds of lathes in general use, with a statement of the points which constitute a good lathe, and a glossary of the technical terms in general use by turners. The second part treats of the use of the hand lathe, and it comprises five divisions, relating to plain turning with hand tools, hand turning in metals, screw chasing, drilling and boring, and miscellaneous operations. The third part enters into a description of a "multi-purpose" lathe designed by Mr. Northcote himself; and this is followed by remarks on self-acting traverse and surface turning, self-acting screw cutting, self-acting drilling and boring, turning irregular shapes, wheel cutting, milling or circular cutter making, fluting or grooving, facing and slot-drilling, planing and slotting, and on attention to lathe, repairing tools, &c. And the fourth part enters into particulars on the subject of ornamental turning.

'The Elasticity, Extensibility, and Tensile Strength of Iron and Steel,'† by Knut Styffe, Director of the Royal Technological Institute at Stockholm. Translated from the Swedish, with an original Appendix, by Chester P. Sandberg, A.I.C.E. With a Preface by John Percy, M.D., F.R.S.. This volume is the result of certain experiments recently made by its author. It contains a full account of those experiments and of the apparatus by the aid of which they were carried out. The subject is divided into four chapters: the first, treating of experiments on tension at ordinary temperatures; the second, on the application of the results of these investigations to the determination of the relative values of steel and iron, and of the different varieties of these materials for various purposes; the third, of experiments on tension at high and low temperatures; and the fourth, of experiments on flexion at different degrees of temperature. To these chapters are also added certain tables and plates, and an Appendix by Mr. Sandberg. The record of these experiments forms a valuable addition to the information obtained by Mr. Kirkaldy on the same subject; much, however, yet remains to be done in the matter of iron and steel testing, and it is to be hoped that further experiments will be undertaken, with the view of arriving at conclusions upon those points which do not as yet appear to have been satisfactorily settled.

* Longmans, Green, & Co., London. † John Murray, London.

7. GEOLOGY AND PALÆONTOLOGY.

(Including the Proceedings of the Geological Society, and Notices of Recent Geological Works.)

Few regions of the earth present to the physical geologist a more wondrous display of volcanic phenomena on a grand scale than the Hawaiian group of islands in the Pacific Ocean. These remote intertropical isles (twelve in number) are all of volcanic origin with the exception of the ancient elevated coral reef and resulting limestone.

Since their first discovery by the Spaniards they have been repeatedly visited by government exploring expeditions, but by far the largest share of their physical history has been collected by one man, the Rev. Titus Coan, for more than thirty years a most devoted missionary at Hilo on Hawaii, the largest of the group. This gentleman sends to 'Silliman's American Journal,'* some interesting notes on the recent volcanic disturbances of Hawaii. Although not on so grand a scale as many of the eruptions which have occurred in former years, yet Mr. Coan's account furnishes information on many points of great interest to the geologist. One feature frequently observed in the volcanic outbursts on these islands is the opening of lateral subterranean rents, into which the overflowing craters discharge their pent-up lava-streams. In the case of the outburst of April, 1868, when the craters of Kilauea and Mauna Loa both seem to have been in a state of eruption, their united lava-streams appear to have discharged into a line of fissure, having a south-westerly trend, along which they flowed subterraneously for a distance of more than thirty miles, appearing on the surface near Kahuku, running thence for ten miles like a vast serpent through the beautiful pasture-lands, and giving off various minor branches, they finally reach the sea in two great streams only 1000 feet apart, enclosing between them an island five miles in length. On this narrow belt of land three houses are left standing near the shore, and some thirty head of cattle were rescued alive (though terribly scorched) after the flow had ceased; so rapid was the rush of the lava-rivers that cattle grazing on the plains were surrounded before they were aware of their danger. A family of four persons in a house were enclosed on an island formed by the igneous flood, and remained prisoners for ten days, when they were able to leave their retreat unharmed.

Along the whole line from Kahuku to Kilauea, the subterranean flow was marked by fissures and displacements of the ground, through which jets of steam and lava issued in several places,

* Vol. XLVII., No. 139, p. 89.

whilst along the hill-flanks the earth was rent, and the surface deposits of earth, boulders, rocks, lavas long-buried, trees, &c., were hurled in one vast avalanche over the plain beneath, a distance of several miles, filling the air at the same time with dry dust. On the night of the earthquake the fires in the great crater went out, and the central area of the great plateau sagged gently down about 300 feet, carrying with it its botanical garden of tree-ferns and "ohelo" bushes (*Vaccinium*) still standing.

A very full account of the entire group with excellent maps and illustrations, and a description of all the modern eruptions, will be found in the recently published 'Memoirs of the Boston Society of Natural History,' by William T. Brigham, A.M.*

Mr. Peacock's book† 'On Evidences of Vast Sinkings of Land on the North and West Coasts of France and the South-Western Coasts of England,' is made up of an *olla podrida* of antiquarian scraps and extracts from the writings of all sorts and conditions of men, from Ptolemy the geographer, A.D. 117, down to Mr. Raphael Pumpelly in 1868.

The author at the end of his labour concludes there is good reason for believing that there has been considerable subsidence on the coast and about the Channel Islands within the historical period, which from an examination of the wear and tear of the coasts on both sides of the Channel, and of the submerged forests on the shores at low water, any geologist would be ready to admit, on geological grounds, without the very doubtful assistance of Ptolemy or Diodorus Siculus.

The tract 'On Steam as the Motive-power in Earthquakes and Volcanoes,'‡ bound up with the above and written by the same author, contains a full compilation of geological authorities in support of the doctrine that steam is the chief agent in volcanic action, but without any original idea, unless the suggestion that the vast necleus of the globe, about 6000 miles in diameter, consists of *pumice*. A serious objection to the book is the badness of the typography and the great number of printer's errors, which render it often unintelligible to the general reader.

Of Mr. Samuel Mossman's 'Origin of the Seasons,§ considered from a Geological Point of View,' the most kind reflection we can make is, "What a pity it was ever written!" Imagine a man suggesting that the curative qualities of the climate of Australia ‖ in

* Vol. I., part iii., 1868.

† 'Physical and Historical Evidences of vast Sinkings of Land on the North and West Coasts of France, and South-western Coasts of England, within the Historical Period.' Collected and commented on by R. A. Peacock, Esq., C.E. 8vo, pp. 190. London: E. and F. N. Spon; and the author, St. Helier, 1868.

‡ Pp. 56.

§ William Blackwood & Sons, Edinburgh, 1869. 8vo, pp. 472.

‖ P. 424.

cases of consumption is due "to the presence of a larger volume of carbonic acid gas in the atmosphere than exists here!!!"

Mr. Mossman's book is a most wonderful compilation of extracts, strung together by such original pieces of fine writing as the following:*—"Let us imagine the sea boiling, bubbling, and steaming above the domes of red-hot trachyte, swelling and bursting as they rose towards its surface, and then ejecting through volcanic cones and yawning fissures such masses of lava as to form so many thousand miles of mountains; let us conceive the shocks and quakes of the earth in this era of her travail, when the pent-up volcanic forces caused her to rend the solid framework of her sphere a perturbed daughter of the sun, the most convulsive child of the solar system."!!

'Geological Fragments collected principally from Rambles among the Rocks of Furness and Cartmel'† (Lancashire), by John Bolton, is a description by a humble geological worker (an entirely self-taught man) of the various excursions in and about Furness and Cartmel, with notes on the formations and fossils to be seen, and the scenes and people among which he has worked; but we hardly think it will be read by many beyond the author's circle of friends.

'Chips and Chapters, a Book for Amateurs and Young Geologists,' is the title of a small 8vo volume of 300 pages, by that indefatigable writer, David Page, LL.D., F.G.S., &c.‡ This is intended as a reading-book for the many, and is an endeavour on the part of the author to put before the general public some of the more prominent facts and bearings of geological science in a readable form. The utility of "Geology as a Branch of Education"§ is a chapter deserving of especial study. We hope the author may be as well satisfied with the sale of his book as we are with its perusal.

On Physical Geology there are contributions by G. Poulett Scrope, "On the Supposed Internal Fluidity of the Earth,"‖ and "On the Influx of Water as the Cause of Volcanic Eruptions;"¶ by Dr. T. Sterry Hunt, "On the Probable Seat of Volcanic Action;"** by Mr. David Forbes, "On the Nature of the Interior of the Earth.'††

In the first paper Mr. Scrope argues in favour of the interior mass of the earth being held down in a solidified form by the

* 'On Volcanic Forces in South America, &c.,' p. 101.

† Ulverston: D. Atkinson; and London: Whittaker & Co. 8vo. 1869. Pp. 264.

‡ Edinburgh and London: Blackwood & Sons. § Pp. 78–104.

‖ 'Geological Magazine' (April), p. 145.

¶ Ibid. (May), p. 196. ** Ibid. (June), p. 245.

†† 'Popular Science Review' (April), p. 121.

weight, cohesion, and perhaps increasing contraction of the solid crust above, yet retaining in this state its intense expansibility, and being ready, at all points, to return to the fluid or gaseous state, and make its escape whenever—by a fissure or disturbance of the superincumbent crust—that pressure is partially removed. In the second paper Mr. Scrope refers to steam as the recognized agent in forcing up lavas through narrow and crooked fissures in the solid crust of the globe, and concludes, from the cellular and porous condition of most lavas, that water was present, in a finely divided state, disseminated through the entire mass. Dr. T. Sterry Hunt calls attention to the views of Keferstein and others, that all crystalline non-stratified rocks, from granite to lava, are but the products of the transformation of sedimentary strata.

Mr. David Forbes concludes, after reviewing the evidences (as to the nature of the interior of the earth) *pro et contra*, that the balance of argument appears to be in favour of the older theory, that the earth is a central molten mass, surrounded or enclosed by a comparatively thin solid crust or shell; and further, seems to indicate the probability that its interior, besides consisting mainly of molten silicates, also contains a great accumulation of the heavy metals and their compounds.

Mr. N. Plant having brought home some plant-remains from Coal-beds of true Carboniferous Age in Brazil,* they have been examined and referred by Mr. Carruthers to the genera *Flemingites*, *Noeggerathia*, and *Odontopteris*.†

Professor Owen has described a remarkably perfect jaw of a Cestraciont fish, from the Oolite of Caen in Normandy, under the name of *Strophodus medius*.‡ Its likeness to the recent Port Jackson Shark is very great.

Mr. Henry Woodward adds a new genus of Ophiuroid Star-fishes to the Upper Silurian of Dudley.§

Mr. Thomas Davidson contributes a series of notes on Continental Geology, relating chiefly to the classification of the Cretaceous system in France, England, Germany, &c.‖

'The Transactions of the Edinburgh Geological Society,'¶ consist of papers read before that Society to May, 1868. "The Carboniferous Strata of Carluke," "The Old Red Sandstone of Scotland," "The Superficial Deposits of the South Esk," "Glacier Action in Galloway, the Coasts of Antrim and Londonderry," "The Miocene Beds of Greenland," "The Precious Stones of Scotland," are among the subjects treated of in this volume. There is every prospect of this Society, which is now under the presidency

* 'Geological Magazine' (April, 1869), p. 147.
† Ibid., p. 151.
‡ Ibid. (May), p. 193.
§ Ibid. (June), p. 241.
‖ Ibid., pp. 162, 199, and 251.
¶ 1868. Vol. I., parts i. and ii.

of Mr. Archibald Geikie (Director of the Geological Survey of Scotland), continuing to do good work.

'The Transactions of the Geological Society of Glasgow'* is marked by Sir William Thomson's celebrated paper "On Geological Time." Considering the motions of the earth, with a careful regard to the effect of resistance and retardation by tidal influence, &c., and viewing the sun as we should any large mass of molten iron, or silicon, or sodium, he comes to the conclusion that: (1) The earth formerly rotated more rapidly than at present, and that its speed is slowly, but certainly diminishing by resistance. (2) That the sun's energies in giving light and heat are being dissipated year by year, and that there is no sufficient supply of new matter falling into the sun's orbit to replenish that energy. (3) That the sun may have illuminated the earth for 100 millions of years, but that it is almost certain that he has not illuminated it for five times that period. (4) From the author's investigations of underground temperatures and the secular cooling of the earth, he infers that the present condition implies either a heating of the surface within the last 20,000 years of as much as 100° Fahr, or a greater heating all over the surface at a more remote period. (5) Sir William Thomson shows, in conclusion, that taking the largest grant of time, and commencing with the earth at a temperature sufficiently high to melt its entire mass, we must admit a limit of between 50 millions and 300 millions of years, beyond which our drafts on the bank of Time cannot be honoured. (6) The Dynamical theory of the sun's heat renders it impossible that the earth's surface has been illuminated by the sun many times 10 million years. (7) Finally, he concludes that the existing state of things—including life on the earth—must be limited within some such period of past time as 100 million years. We should like to notice Messrs. James Geikie, "On Denudation in Scotland since Glacial Times;" Archibald Geikie, "On Modern Denudation," and "On the Silurian Rocks of Scotland;" Mr. Edward Hull, "On the Causes which seem to have regulated the relative Distribution of the Calcareous and Strata of Great Britain, with special reference to the Carboniferous Formation;" besides many other excellent papers, but our space does not permit.

Proceedings of the Geological Society of London.

The May number of the 'Quarterly Journal'† furnishes us with the Annual Report, the Anniversary Address by the President, and the papers read before the Society from December 23, 1868,

* 1868. Vol. III., part i.

† Edited by Mr. W. S. Dallas, the new assistant-secretary.

to February 24, 1869. The income expected this year (1869) amounts to 2072*l.* 16*s.*, and expenditure to 1893*l.*, leaving a balance in favour of the Society of 179*l.* 16*s.*; whilst the funded property amounts to 4860*l.* 14*s.* 6*d.*, exclusive of trust-fund. We may, from the above statement, safely congratulate this learned body upon its healthy financial condition. The President (Prof. Huxley) takes, as the text for his Anniversary Address, the subject matter of Sir William Thomson's article "On Geological Time," already briefly epitomized in this present Chronicle.

Commencing with a brief review of the various lines of thought which a study of geology has developed, the author divides them into three classes—Catastrophists, Uniformitarians, and Evolutionists; with the two former classes of thinkers we were well acquainted, but the third is a new class, defined as those who "embrace in one stupendous analogy the growth of a solar system from molecular chaos, the shaping of the earth * * * to its present form, and the development of a living being from the shapeless mass of protoplasm we term a germ."

Assuming that Sir W. Thomson is correct in asserting that life on the earth must be limited to 100 million years, Professor Huxley shows that the whole thickness of stratified rocks, taken at 100,000 feet, or about 56¾ miles, could have been formed within that period of time if only $\frac{1}{1000}$ of a foot or $\frac{1}{83}$ of an inch of sediment were deposited annually.

He points out that although so much stress is laid by Sir W. Thomson on retardation, yet "it is not absolutely certain, after all, whether the moon's mean motion is undergoing acceleration, or the earth's rotation retardation; and yet this is the key to the whole position." "If the rapidity of the earth's rotation is diminishing, it is not certain how much of that retardation is due to tidal friction, how much to meteors, how much to possible excess of melting over accumulation of polar ice during the period covered by observation, which amounts, at the outside, to not more than 2600 years."

One of the most acute and telling remarks in the address is that contained in the following paragraph:—

"I do not presume to throw the slightest doubt upon the accuracy of any of the calculations made by such distinguished mathematicians as those who have made the suggestions I have cited. On the contrary, it is necessary to my argument to assume that they are all correct. But I desire to point out that this seems to be one of the many cases in which the admitted accuracy of mathematical processes is allowed to throw a wholly inadmissible appearance of authority over the results obtained by them. Mathematics may be compared to a mill of exquisite workmanship, which grinds you stuff of any degree of fineness; but, nevertheless, what

you get out depends on what you put in; and as the grandest mill in the world will not extract wheat-flour from peascods, so pages of formulæ will not get a definite result out of loose data."

The most important papers contained in the 'Journal of Proceedings' are Mr. T. W. Kingsmill's communication on the Geology of China, especially with reference to the Province of the Lower Yangtse; Prof. Huxley's paper "On the genus *Hyperodapedon*," a reptile found in the Triassic deposits of Elgin (once said to be of Devonian age). From remains found of late in Warwickshire and Devonshire the author has determined its Lacertilian character, and considers its nearest fossil ally to be the Triassic genus *Rhynchosaurus*, and at the present day the singular genus *Sphenodon*, or *Hatteria*, found in New Zealand.

Mr. Edward Hull has an ingenious and suggestive paper "On the Evidence of a Ridge of Lower Carboniferous Rocks crossing the Plain of Cheshire beneath the Trias, and forming the Boundary between the Permian Rocks of the Lancashire Type on the North, and those of the Salopian Type on the South."

The Rev. T. Wiltshire, "On the Hunstanton Red Chalk," adds to our knowledge of this interesting local deposit, which from all the evidence, both lithological and palæontological, appears to be the representative at Hunstanton of the upper portion of the Gault of Folkestone.

The other papers are: Messrs. King and Rowney "On the so-called 'Eozoonal' Rock;" Mr. Whitaker "On the New Locality for *Hyperodapedon* on the coast of Devon;" Mr. W. H. Baily "On the Irish Graptolites" and "On Tertiary Plant-remains from Antrim;" Mr. G. T. Clark "On the Basalt Dykes of India;" Dr. Sutherland "On the Auriferous Rocks of South-eastern Africa;" Mr. W. Boyd Dawkins "On the Distribution of the British Post-Glacial Mammals;" and a postponed paper by Mr. J. Wood Mason "On *Dakosaurus*, from the Kimmeridge Clay of Shotover Hill."

8. METEOROLOGY.

In a recent part of the Proceedings of the Meteorological Society there is a very suggestive paper by Mr. Meldrum, containing some interesting results as to the origin of cyclones in general, to which he has been led by his study of the weather of the Indian Ocean. In our last number we noticed the Synoptic weather charts which Mr. Meldrum is preparing for publication. The examination of these charts affords abundant confirmation of an idea which he has long entertained, and which is traceable in many of his papers, *viz.*

that most of, if not all, the atmospherical disturbances experienced in those seas may be referred to the mutual interference of the two great currents of air, whether these be the ordinary polar and equatorial currents, the S.E. and N.W. winds of the South Temperate Zone, or the S.E. trade and the N.W. monsoon met with nearer the equator. When these opposite currents are flowing in parallel channels at the earth's surface, the resulting action on the atmosphere in general differs according to their position as regards latitude. When the bed of the polar current is in a latitude higher than that of the equatorial, *i.e.* when the S.E. wind lies to the southward of the N.W. wind, atmospherical pressure has a tendency to decrease between them, and ultimately the wind begins to circulate round the area of depression, in the direction of the hands of a watch. A cyclone is ultimately formed, and in it the force of the wind is stronger at the centre than at the circumference. When the position of the currents is reversed, a barometrical maximum is produced, around which the wind revolves in the direction opposite to that of the hands of a watch. In short an "anticyclone" is formed, in which the wind-force is usually very light in the centre but stronger outside. It is hardly necessary to observe that as we are dealing with the Southern Hemisphere, the conditions of the direction of the wind's motion are exactly the reverse of what obtains in this hemisphere. Mr. Meldrum asserts that cyclones *invariably* have their origin as we have described. They commence at the southern edge of the N.W. monsoon, and travel obliquely across the S.E. trade.

If this theory be found to be completely trustworthy, we may hope that it will be possible to assign an origin to the West Indian hurricanes, which will be more satisfactory than that given hypothetically by Dove, who attributes them to the fact that by some means or other a portion of the upper current (antitrade) between the tropics has been forced out of its proper stratum into the true trade wind below it, so that an eddy, ultimately resulting in a hurricane, has been formed. This is, after all, something like the convulsion theories of the older geologists. If we can find that ordinary causes are capable of producing certain effects, it is well to satisfy ourselves, whenever these effects are observed, that these causes were not in operation, before we call in a *deus ex machinâ* of any sort to produce the required action.

We see from the report of a lecture delivered at the Royal Institution on April 30 by Mr. Scott, that the Meteorological Office has been led, independently of Mr. Meldrum, to results similar to his, and we may hope that useful results will come out of the inquiry.

The Journal of the Scottish Meteorological Society for January contains a good paper by Mr. Buchan "On the Mean Monthly and

Annual Pressure in Scotland." He has investigated the returns from fifteen stations for eleven years, and the results obtained afford, as might be expected, a strong corroboration of the principle that the motion of the air is related to the differences of atmospherical pressure. The mean annual pressure decreases from east to west and from south to north, and as the wind always blows with the lowest barometrical reading on its left hand side, we see that the general conditions of pressure are in harmony with the fact that our prevalent winds are south-westerly.

The monthly curves exhibit three minima and three maxima; the former occurring in January, March, and October; the latter in February, May, and November.

The depression in January increases as we go northwards, while that in March changes in the opposite direction. In October the decrease is nearly uniform over the whole of Western Europe.

As regards the maxima, that in February is of slight extent. In May the absolute maximum for the year is reached, corresponding to the period of prevalence of our east winds. The increase of pressure in November is the phenomenon so long noted as the great November wave, to which it is not now the fashion to attribute nearly so great an influence on our weather as it was some few years ago. This paper is a very useful contribution to meteorology, as the results of eleven years' observations may be fairly considered as worthy of attention.

The 'Atlas Météorologique' for 1867, published by the Observatoire Impérial, contains an elaborate paper by M. Becquerel, on the influence of forests on climate. The paper is very carefully written, but on reading it proves somewhat disappointing, as it leads to very few practical results, owing to a deficiency of evidence on many questions.

There is one action which all vegetation, of whatever character it be, exerts, and that is the protection of the soil on which it grows from forcible removal by floods. The roots traverse the earth in all directions, and bind it together, while the branches break the force of the rain as it falls. As soon as a hill-side is cleared of forests, the rivulet-beds are scored deeper and deeper, and the soil is gradually washed down, leaving the rocks bare. The roots of trees have, in addition, a tendency to facilitate the percolation of water to the subsoil, and thus to prevent its accumulation on the surface, and the consequent production of swamps, such as have been formed in parts of France within historic times. There is another beneficial effect produced by trees, that of impeding the motion of the air, and thus affording shelter from wind. This action is, of course, limited, depending on the height of the trees and the direction of motion of the wind. If this direction be horizontal the shelter afforded is very considerable, as it has been

noticed in Provence that a hedge two mètres in height shelters a space 22 m. in width from the effects of the "mistral." Lastly, trees have a decided influence on health, in protecting a district from unwholesome exhalations. It is found along the edge of the Pontine marshes that the existence of a belt of wood is sufficient to ensure immunity from malaria to the peasants who live behind it. These then are the most obvious beneficial effects on climate of the presence of forests in a country. As regards the direct influence of vegetation on the temperature and the climate generally, the author gives the notes of some experiments which he has made on growing trees, in order to determine their temperature and that of the surrounding air at different times of the day. The results seem to show that trees behave as if they were dead or inorganic bodies, receiving heat from external sources and radiating it to surrounding objects. The heat developed in the process of growth was found to be quite inappreciable by means of the instruments employed, while the cooling influence usually assigned to foliage, owing to the constant evaporation going on from its surface, was shown to be utterly unfounded. However, this part of the paper is quite incomplete, as M. Becquerel reserves the exact account of his inquiry for a future essay. He distinctly denies the truth of the change of climate alleged to have taken place in various countries, and attributed to the clearing of the land, without, as it seems to us, investigating the question thoroughly.

The ultimate conclusions stated in the paper are, as we have said before, unsatisfactory; *e. g.* we are told that the effect of cutting away the forests is to diminish the quantity of running water in the country, but the comparison of observations of rainfall in a district, before and after the clearing, have most decidedly *not* led to the conclusion that the amount of rain which falls is seriously affected by the clearing. We do not therefore learn to what action the reduction of the amount of river water is to be attributed.

On the whole the paper may be fairly compared to Darwin's first work 'On the Origin of Species.' Both works contain many facts of great interest which have a certain relation one to another, while the reasoning which should bind the whole together is for the most part entirely wanting. We hope that M. Becquerel's promised paper will be more conclusive than this one.

Before we leave the subject of meteorology in France, we should say that it appears from the Bulletin Hebdomadaire of the Association Scientifique, that the plan for the establishment of a central Physical Observatory in Paris and the proposed modifications in the management of the Observatoire Impérial, the result of which would have been to put a stop to all but the astronomical work carried on there, have both been brought to an end. M. Le

Verrier announces that the Observatoire will continue to perform all its functions as heretofore.

The Norddeutsche Seewarte, in Hamburg, has published its first Annual Report, and Herr Von Freeden, the Director, promises two other publications within a brief space. These will be an account of the German North Polar Expedition of last year, under Captain Koldewey,* and a weather calender for north-west Germany, the latter being the discussion of his own observations made at Bremen during the past ten years. The Report is to a great extent taken up with the account of the preliminary negotiations which led to the establishment of the Seewarte by the shipowners of Hamburg and Bremen. Marine meteorology has been the chief object of the institution, and the director has set to work very vigorously in this line. In order to induce the shipping interest of the towns to co-operate warmly in the work of the office by making observations at sea, the direction has proceeded to frame minute sailing directions for the several voyages, and the Report contains a practical proof of the value of scientific meteorology to trade, in the form of a tabular statement of the total amount of gain in time exhibited by the runs made by vessels furnished with these directions, as compared with passages made by other ships between the same ports at the same time. The sailing directions are very definite in their character, for one of the objects of their issue has been to supply information more thoroughly digested, and in fact more practical than Maury's works can afford.

The Report is professedly only the account of the activity of one department of the office, but hopes are held out that at some future time its operations may be extended to land meteorology also. The only work of this nature which is carried on is the publication of daily observations made at Hamburg, and of occasional storm telegrams received from our own Meteorological Office. It is interesting to see that these messages have been of practical use, notwithstanding the great distance of Hamburg from London, for out of thirty-seven messages sent, more than half were followed by storms, while in only three instances did the storm precede the warning.

The long promised charts of surface temperature for the South Atlantic Ocean have now been published by the Meteorological Committee. They contain the mean monthly surface temperatures for five-degree squares, calculated from the data collected by Admiral Fitz Roy out of Board of Trade registers, and in addition the mean temperatures for strips of 5° of longitude, but for each degree of latitude published in 1861 by the Meteorological Institute

* This work has already been published, but a notice of it must be reserved for the next Chronicle.

of Holland. The charts are illustrated by copious notes, consisting of extracts from the logs of captains, who have noticed sudden changes of temperature and thus tending to show where the actual boundaries of the various ocean currents lie.

Meteorologists will hail these charts as a useful contribution to Marine Meteorology, and as a first instalment of the publication of the partly finished work found by the committee in the office when they took charge of it.

We are glad to learn that H.M.S. 'Porcupine' has been placed at the disposal of Dr. Carpenter and his friends, in order to carry out a more extensive series of deep-sea soundings and dredgings than was possible during their short cruise last autumn. We hope that by this expedition some light may at last be thrown on the vexed question of deep-sea temperatures.

Mr. S. Barber sends us the following account of the Aurora Borealis, observed by him near Liverpool. The two remarkable appearances of Aurora Borealis which occurred lately, afford some peculiar and noteworthy points of comparison, in addition to the fact of their unusual brilliancy and striking form, and their proximity to each other; the last in point of time, on May 13th, showed greater steadiness and a whiter light, the flashes being feeble and indistinct. The rays of electric light, arched, broad, and white, over the entire heavens, converging to an irregular nucleus, situated about 10 degrees S.S.E. of the zenith. This nucleus had a jagged edge and an irregular cavity within it, and its form changed rapidly, one half of its body disappearing in less than a minute. The space between the streamers was very small, and a very light greenish blue colour produced a remarkable effect. The previous Aurora presented much stronger contrasts of colour, and greater radial definition. The light was more limited in extent, and the rays most distinct from north to west, from which quarter, and from N.W., were rapid and brilliant flashing streamers, having a wave-like and tremulous motion, as of bands of ribbon violently shaken; these converged, as in the former case, to a point not far from the zenith, and nearly coincident with that of the nucleus in May. It is worthy of notice that a long period of cold wet weather followed these remarkable phenomena, the wind ranging from east to north. The above notes were taken from about 10 to 11½ P.M.

9. MINERALOGY.

Exactly eighty years ago, the German chemist, Klaproth, discovered a new earth, or metallic oxide, in a certain mineral found in the sands and gravels of Ceylon, and occasionally cut and polished as a gem. As this mineral had long been known under the name of *zircon*—a word apparently of Arabic origin—the new earth received the appropriate name of *zirconia*. The same oxide was likewise found in the brightly-coloured stone known as the *hyacinth*—not indeed the hyacinth of the ancients, which appears to have been our sapphire, but the gem so-named by the modern mineralogist—and it was then demonstrated that the zircon and hyacinth are virtually the same mineral, both being silicates of zirconia. In 1845, the Swedish chemist, Svanberg, endeavoured to show that in the zircons of Norway and of the Urals the zirconia is accompanied by another substance which he termed *noria;* but whether this is really a distinct earth has not been satisfactorily determined. About three years ago, Professor Church was led to examine several specimens of zircon under the micro-spectroscope; and observing that some of them exhibited peculiar absorption bands, not given by pure silicate of zirconia, he conjectured that they might possibly be due to the presence of Svanberg's norium. Utterly ignorant of Professor Church's observations—the results of which were published only in the shape of a letter inserted in a popular journal—Mr. H. C. Sorby has for some time past been engaged in the spectroscopic examination of the zircons of Ceylon. When light is transmitted through certain transparent specimens of zircon, and is then analyzed by the eye-piece of his spectrum-microscope, it is seen that the luminous spectrum is traversed by more than a dozen well-defined narrow black lines. As these absorption bands are not given by any other known substance, Mr. Sorby regards them as indicating the presence of a new earth associated with zirconia; and as they are exhibited chiefly by those pale-coloured varieties of zircon which are known as *jargoon* or *jargon*, he proposes to name the new metal *jargonium*. Professor Church, however, has suggested for this supposed element the name of *nigrium*. It would appear from Mr. Sorby's further researches that the earth jargonia is capable of existing in two distinct allotropic conditions, having different densities and different optical properties. Comparatively few Cingalese jargons exhibit in their natural state well-marked lines, but by exposing an ordinary specimen for some time to a bright-red heat the altered mineral gives a spectrum which is traversed by a fine series of absorption bands.*

* 'Chemical News,' March 12, April 16 and 30, 1869; also paper printed for private circulation at soirée of the Royal Society.

In association with Mr. P. J. Butler—a gentleman possessing a fine collection of gems—Mr. Sorby has presented to the Royal Society a paper "On the the Structure of Rubies, Sapphires, Diamonds, and certain other Minerals."* They find that the sapphire exhibits numerous cavities, sometimes reaching $\frac{1}{10}$th of an inch in diameter, and either partially or entirely filled with a liquid—probably condensed carbonic acid. Small triangular lamellar crystals are also to be noted as common inclosures in this gem. The ruby differs from the sapphire—although of course chemically the same stone—in that it contains fewer fluid-cavities and more included crystals, some of which are octohedral in form, and are probably minute spinel rubies. In certain spinels from Ceylon, the fluid-cavities contain a colourless liquid, accompanied by either a solid substance or a very viscous fluid in which small crystals are embedded. Many emeralds are extremely full of fluid-cavities, containing what appears to be a strong saline solution with cubic crystals—probably of chloride of potassium. By examining several diamonds, the authors find that the embedded black specks, which Brewster imagined might be cavities, are really inclosed crystals. Some of these are surrounded by cracks indicating contraction in the neighbouring mass; and this indication is strengthened by the appearance of a black cross surrounding the crystals when examined by polarized light. The authors' general conclusions drawn from these observations "seem to show that the ruby, sapphire, spinel, and emerald were formed at a moderately high temperature, under so great a pressure that water might be present in a liquid state. The whole structure of the diamond is so peculiar that it can scarcely be looked upon as positive evidence of a high temperature, though not at all opposed to that supposition."

When Mr. David Forbes, more than eighteen months ago, published the first part of his researches in British mineralogy, he described at length the results of his examination of our Welsh gold. Since then, his attention has been directed to the gold-bearing districts of England, Ireland, and Scotland, as represented respectively by the counties of Cornwall, Wicklow, and Sutherland.† By examining specimens from each of these localities, Mr. Forbes is enabled to place in our hands a series of analyses of gold from every quarter of the British Isles—a series peculiarly valuable, inasmuch as our knowledge of the chemical composition of British gold has hitherto been remarkably defective. As we have already published

* 'Proceedings of the Royal Society,' xvii., No. 109, p. 291.
† 'Philosophical Magazine,' May, 1869, p. 321.

his analyses of Welsh gold,* we need only here quote the English, Irish, and Scotch analyses:—

	Cornwall.		Co. Wicklow.		Sutherlandshire.		
Specific gravity ..	16·52	....	15·07	....	15·799		
					I.		II.
Gold	90·12	....	91·01	....	81·11	..	81·27
Silver	9·05	....	8·85	....	18·45	..	18·47
Silica†	0·83	....	0·14	....	0·44	..	0·26
	100·00	....	100·00	....	100·00	..	100·00

On examining these analyses, one cannot fail to remark the large amount of silver alloyed with the Sutherlandshire gold as compared with the proportion present in gold from other parts of the British Isles. Any remarks on the occurrence and distribution of our native gold are rendered unnecessary by Mr. Robert Hunt's excellent paper on the subject published in a former volume of this Journal.‡

A Devonshire mineral, used at one time as an iron-ore, has been found by Mr. Forbes to have the composition of *Babingtonite*—a rare species, found chiefly at Arendal, in Norway. Our British Babingtonite presents a radiated fibrous structure, a blackish-green colour, and a composition represented by the formula:—

$$6\,CaO\ .\ SiO_2 + 3\,FeO\ .\ SiO_2 + Fe_2O_3\ .\ 3\,SiO_2.$$

On more than one occasion it has been our duty to call attention to Vom Rath's discovery of a new form of silica called *Tridymite*. Professor Maskelyne has lately found this interesting species, or a very closely-allied mineral, in the meteorite of Breitenbach, in Bohemia.§ The crystals, although imperfect, are apparently hexagonal in form, whilst their composition shows them to consist of almost pure silica. From these characters alone, the mineral might perhaps be mistaken for quartz, but as its specific gravity is not above 2·245, there can be but little doubt that we are here dealing with a species closely akin to tridymite, occurring under conditions altogether novel. The crystals are found in the hollows of the meteoric iron, where they are accompanied by pale-green prismatic crystals having a composition nearly agreeing with that of enstatite.

Two or three new American meteorites have been described by Professor C. U. Shepard.‖ One of these is a meteoric iron, from Auburn, Macon Co., Alabama. Its chief peculiarity consists in its fissured structure, which gives it an appearance—to use the Pro-

* 'Quart. Journ. Science,' v., p. 101.
† With sesquioxide of iron in the Cornish specimen.
‡ Vol. ii., p. 635.
§ 'Proc. Royal Society,' xvii., p. 370; 'Chem. News,' April 16, 1869.
‖ Silliman's 'American Journal of Science,' xlvii., p. 230.

fessor's own words—"as if it had been shattered by striking when in a semi-fused state, against a rock, at the time of its fall." A description is also given of another meteoric iron, now in the St. Louis Academy of Sciences; and an analysis is published of the Losttown meteorite, previously noticed in this journal.* We have only space to give the percentages of the chief constituents in each specimen :—

	Auburn.		St. Louis.		Losttown.
Iron	94·580	....	92·096	....	95·759
Nickel.. ..	3·015	....	2·604	....	3·660

When a polished section of meteoric iron is etched with an acid, it is well known that a peculiar crystalline structure is usually developed. The markings thus produced are known, after their discoverer, as the Widmannstätten figures. Dr. J. Lawrence Smith has recently found that certain meteorites from Trenton, Washington Co., Wisconsin, exhibit on similar treatment a distinct set of markings, different from those of Widmannstätten; and as his attention was first directed to them by a Mr. Lapham, he proposes to distinguish them as the *Laphamite figures.* The meteorites exhibiting these figures contained 91·03 per cent. of iron, and 7·2 of nickel.†

What is really the formula of that curiously-constituted mineral, *Haüyne?* On collecting the published analyses, it will be found difficult to reconcile their discrepancies. Dr. Kenngott has recently found that sulphate of soda may be obtained by the action of water on haüyne, and hence he believes that some of the recorded analyses have been made on specimens partially altered in this manner. Allowing for such an action, he regards the unchanged mineral to be constituted according to the following formula,‡ which indeed agrees with that deduced from Whitney's analysis of the Alban haüyne, namely :—

$$3\,\{(Na_2\,.\,Al_2)\,O_4\,.\,2\,Si\,O_2\} + 2\,(Ca\,O\,.\,S\,O_3).$$

Further contributions to the mineralogy of Nova Scotia have been published by Dr. How.§ Among these will be found notices of a carboniferous lignite, from Pictou Co., and of the species Turgite, Delessite, and Fahlunite. A new locality is given for the interesting Acadian mineral described in a former number of this Journal under How's name of Silicoborocalcite,‖ but which has since been appropriately named *Howlite.*

In compliment to the well-known Italian geologist, Quintino

* Vol. vi., p. 134.
† 'Silliman's Journal,' xlvii., p. 271.
‡ Leonhard und Bronn's Jahrbuch für Mineralogie. 1869, Heft 3, p. 329.
§ 'Phil. Mag.,' April, 1869, p. 264.
‖ Vol. v., p. 259.

Sella, the name of *Sellaite* has been appropriated to a new species described by Strüver.* The mineral is apparently a simple fluoride of magnesium, and crystallizes in small, transparent, prismatic forms, embedded in the anhydrite of Montiers in Savoy.

Associated with the cryolite of Ivigtok, in Greenland, a new species has been found, and named after the locality. *Ivigtite* appears to be a silicate of alumina, soda, and protoxide of iron, with a little fluorine.†

In a peculiar variety of hyperite occurring in the parish of Eura, in S. W. Finland, a mineral is met with, to which Herr Wiik applies the name of *Euralite.*‡ Its composition approaches that of delessite.

Professor Reichardt has recently published analyses of the *Polyhalite* which occurs in large nodular masses scattered through the so-called "polyhalite region" of the salt-deposits of Stassfurt, in Prussian Saxony.§

Picotite is a mineral bearing close kindred to spinel, and found in octohedral crystals in certain forms of olivine rock. Dr. Petersen has lately examined specimens from the Dun Mountain in New Zealand, and is thus led to establish two types of the species—a *chrome-picotite* and an *alumina-picotite.* The Doctor has likewise examined the *magnetic pyrites* of Auerbach, and regards its formula as FeS instead of Fe_7S_8, as generally written. Finally, he publishes some analyses of *red silver-ores,* both "dark" and "light," or in other words, both antimonial and arsenical.‖

10. MINING, METALLURGY, AND THEIR RECENT LITERATURE.

Mining.

In our last number we noticed the fact that the ancient Stannary Court of Cornwall was about to undergo a change, a Bill having been introduced for its amendment. Numerous alterations have been made in the Bill since its first reading; it has been read the second time; and no doubt, before these pages are in the hands of our readers, the Stannary Court Act will have become the law of the future for the Stannaries of Cornwall and Devonshire.

* Atti della Reale Accademica delle Scienze di Torino.
† Silliman's Journal, xlvi., p. 400.
‡ Öfv. af Finska Vet. Soc. Förh. 1869, xi., p. 28.
§ Leonhard u. Bronn's Jahrbuch. 1869, Heft 3, p. 325.
‖ 'Journal für praktische Chemie,' 1869, No. 3, pp. 134, 137, 141.

The dues paid to the Stannary Court upon the ores raised within its jurisdiction have been for the last two years as follows:—

Cornwall.

	1867.							1868.						
	Quantities.				Value.			Quantities.				Value.		
	Tons.	cwt.	qrs.	lbs.	£	s.	d.	Tons.	cwt.	qrs.	lbs.	£	s.	d.
Tin Ore	10,848	9	3	27	538,006	19	4	11,216	18	0	22	621,083	1	5
Tin in Stone	140	0	0	0	7,230	17	7	201	0	0	0	11,162	9	11
Copper Ore	81,663	9	2	0	379,197	18	5	78,012	14	3	0	341,602	1	10
Lead Ore	8,615	18	1	0	138,676	13	7	8,303	11	3	0	137,197	11	6
Zinc Ore	1,674	6	0	0	4,097	1	9	1,852	7	0	0	4,921	1	1
Silver Ore	—	—	—	—	—			—	5	3	18	10	19	3
Iron Pyrites	8,229	15	0	0	8,658	4	4	6,914	1	1	0	6,762	10	5
Arsenic	1,200	0	0	0	2,074	11	2	1,267	4	3	0	3,608	19	10
Wolfram	10	10	0	0	62	0	0	9	4	0	0	67	6	7
Ochre and Gossans	730	10	0	0	422	12	2	151	5	0	0	89	4	4
Nichel	1	17	1	0	14	12	5	—	—	—	—	—	—	
Fluor Spar	—	—	—	—	—	—		60	0	0	0	42	0	0
Iron Ore	5,418	10	0	0	1,675	16	1	6,545	11	0	0	1,994	1	6
Total	118,533	5	3	27	1,080,117	6	10	114,534	3	2	12	1,128,541	7	8

Devonshire.

	1867.							1868.						
	Quantities.				Value.			Quantities.				Value.		
	Tons.	cwt.	qrs.	lbs.	£	s.	d.	Tons.	cwt.	qrs.	lbs.	£	s.	d.
Tin Ore	78	8	0	14	4,137	10	2	54	3	2	13	3,085	17	7
Copper Ore	30,442	10	0	0	139,265	13	4	27,465	3	2	0	118,811	0	3
Lead Ore	449	18	3	0	11,967	1	10	473	5	3	0	6,206	12	5
Iron Pyrites	646	6	1	0	353	17	7	685	3	3	0	496	14	6
Arsenic	56	5	1	0	37	19	4	473	10	3	0	2,802	12	11
Ochre and Gossans	33	18	0	0	39	7	3	27	2	2	0	62	10	10
Iron Ore	7,396	1	0	0	2,277	11	9	3,563	17	0	0	1,069	3	1
Total	39,103	7	1	14	158,079	1	3	32,742	6	3	13	132,534	11	7

It should be explained, that the above returns do not represent the actual total production of the mines of the two western counties, which are comprehended within the Stannaries. They do so very nearly; but it generally happens that some of the less important mines do not make their returns for some time after the termination of the year. The quantity of arsenic produced in 1868, being nearly 420 tons more than that obtained in 1867, should be explained. It arises entirely from the extensive and very complete arrangement made at the Devon Great Consolidated Mines, near Tavistock, for subliming the arsenic from the vast heaps of Arsenical Pyrites which have accumulated on their floors.

"A Bill to Consolidate and Amend the Acts relating to the Regulation and Inspection of Mines" has been introduced to the House of Commons by Mr. Secretary Bruce and Mr. Knatchbull-Hugessen, and read a second time.

In its present form the Bill does not appear to satisfy any one. The coal-owners and the coal-workers equally complain. On the

one hand, the owners feel aggrieved at the additional responsibilities which are thrown upon them; and on the other, the colliers say they receive no more real protection by this Bill than they did under the old Inspection Acts. The Mining Association of Great Britain is meeting from time to time to watch the progress of matters affecting the interests of the coal trade, and sundry amendments have been proposed to the Government by that body. The working colliers have also had several meetings, and, by their delegates, they urge the Government to appoint additional inspectors, or to create a class of sub-inspectors.

The principal novelty in this Bill is the clause making it compulsory that plans of all abandoned collieries should be lodged with the Secretary of State, within three months from the time when the coal within the pit has been abandoned. There appears to be some difficulty in the way of carrying out this excellent provision. It is thought that the plans so deposited may be used to the injury of the individual. This, however, may be guarded against, by enacting that such plans shall not be evidence in a court of law, and that no action can be founded on evidence obtained by inspecting those plans or maps. As a means of protecting the lives of the miners, it is important that all information respecting our subterranean workings should be preserved. It is therefore to be hoped that this clause may, with well-considered restrictions, become a portion of the new Inspection Act.

COAL.—The production of coal in these islands was in 1867, according to the returns given in the "Mineral Statistics," 104,500,480 tons. In 1868, according to the returns of the Inspectors of Coal Mines, the quantity was 104,566,959 tons. Of this the exports, according to the returns of the Board of Trade, were as follows:—

NAME OF COUNTRY.	Quantity.	Declared Value.
	Tons.	£
Russia	623,767	306,103
Sweden	336,099	162,971
Denmark	835,669	367,721
Prussia	583,450	239,101
Hanse Towns	767,744	346,393
Holland	260,048	126,004
France	1,925,370	872,492
Spain and Canaries	524,161	294,248
Italy—Sardinia	288,852	145,590
United States	103,851	72,046
Brazil	293,577	172,393
British India	542,570	293,003
Other countries	3,752,355	1,957,726
Total	10,837,513	5,355,791

The report of the Colliery Inspectors for 1868 has been recently published. The following table has been compiled from that document:—

A RETURN showing the QUANTITY of COAL RAISED in and about the COAL MINES of GREAT BRITAIN; the NUMBER of FATAL ACCIDENTS and LIVES LOST by the ACCIDENTS, in the Year 1868.

NAMES OF DISTRICTS.	Number of Collieries.	Quantity of Coal Raised.	Separate Fatal Accidents.	Lives Lost by the Accidents.
		Tons.		
Northumberland, Cumberland, & North Durham	175	11,400,000	67	69
South Durham	171	15,300,000	84	87
North and East Lancashire	292	7,053,000	61	65
West Lancashire and North Wales ..	208	7,600,000	126	237
Yorkshire	459	9,705,000	77	80
Derby, Nottingham, Leicester, and Warwickshire	195	7,699,000	58	60
North Stafford, Cheshire, & Shropshire	225	6,000,000	57	61
South Stafford and Worcestershire ..	550	9,900,000	90	104
Monmouth, Gloucester, Somerset, and Devonshire	230	6,200,000	59	61
South Wales	329	9,000,000	100	104
Totals: England and Wales	2834	89,857,000	779	928
East Scotland	254	8,456,084	41	43
West Scotland	203	6,253,875	40	40
Totals: Scotland	457	14,709,959	81	83
Totals: England, Wales, & Scotland	3291	104,566,959	860	1011

It should be noted that all the collieries given were not at work in 1868—from two to three hundred were probably idle; we may therefore consider the number of working collieries at about 3000.

The imports of COAL and COKE to France were, according to official French returns in 1868:—

	COALS.	COKE.
	Tons.	Tons.
From GREAT BRITAIN	1,885,000	3,800
„ BELGIUM	3,718,000	448,200
„ GERMANY	1,389,000	212,700
„ OTHER COUNTRIES ..	1,000	300
Totals	6,993,000	665,000

MINERAL OILS.—M. St. Claire-Deville has recently brought before the *Académie des Sciences* a most useful memoir on the

calorific value of the mineral oils, the result of a series of experiments which he has carried out by order of the Emperor. The results to which these experimental trials have led this eminent chemist are—

"En général, cette chaleur est plus faible que celle qu'on calcule par la loi de Dulong, et les chaleurs de combustion de l'hydrogène et du carbone déterminées par MM. Favre et Silbermann, si l'on opère sur les huiles non oxygénées. Au contraire, pour des huiles fortement oxygénées comme de l'huile de houille, on trouve une chaleur plus grande que la chaleur calculée par la loi de Dulong. Ces limites seraient donc dans la catégorie des corps explosifs qui contiennent plus de chaleur que les éléments qui les constituent n'en possèdent à l'état isolé."

The distillation of oils from the bituminous shales and cannel coals of this country has within the past quarter shown a disposition to revival. The influx of American oils entirely stopped the production of oils in these islands, by reducing the price. The demand for the mineral oils and paraffin is increasing, prices are advancing, and consequently, in many places, fires are being relighted under retorts which have been for the last two years in a state of repose.

Gold.—The quantity of gold raised during the first quarter of this year at Vigra and Clogău, in Merionethshire has been somewhat in excess of that produced in the corresponding quarter of last year. Some other quartz lodes have been opened on in the Dolgelly district with very promising results.

With the approach of fine weather the Helmsdale diggings in Sutherlandshire have attracted a large number of miners. An interesting popular account of those "diggings" has been written by J. F. Campbell, Esq., of Islay, called 'Something from the Gold Diggings in Sutherland.' Mr. Campbell states "that more than 290 men are paying a pound a month for leave to camp out and work like navvies in claims of 40 feet square; so that they must be earning wages or going crazy." From the best authority we are enabled to state that about 2000*l.* worth of gold has been found since the Helmsdale burns have attracted attention.

Platinum has been, according to the 'Mining Journal,' discovered in Scotland. It is said to have been found in some auriferous Scotch quartz, and, as we glean, in connection with the gold deposits which have been exciting attention. We are disposed to think this to be very problematical, and await some further information. That some very minute particles of platinum were found in the auriferous sands of Wicklow, some years since, is certain, but no quartz in the British Isles has ever yet been found to contain that metal.

Gold is reported to have been found in considerable quantities in the region of the Cape of Good Hope, mainly in the great plateau north of the Sneeuwbergen to the Orange river. Although some doubts have been thrown on the discovery of diamonds at the Cape, it appears tolerably certain that about thirty of those valuable gems have been found. Dr. Muskett, of Hope Town, writing to the Society of Arts, says the formation in which those gems are found "consists of rolled quartz, pebbles of various sorts, chalcedony, agates, quartz crystals, bloodstone, Lydian stone, &c., fixed in a matrix of sandstone, and it rests on a regular sandstone formation."

The Miners' Association of Cornwall and Devonshire has just issued its annual report. From this it appears that in 1868 fifty-one students in the classes passed the examinations of the Department of Science and Art. The Rev. Saltren Rogers, one of the Vice-Presidents, states:—"The pupils have been gathered partly from working miners; more from a class above them, sons of mine agents, shopkeepers, schoolmasters, and the like. Though it might be wished that a larger proportion of the former were among our pupils, it is nevertheless very important that a stimulus to scientific studies should be given among the latter; it is through them, and not through the working miner, that we must look for a higher and more general appreciation of such studies; it is from men that have had the preparatory elementary education which they have had, that we may expect inventive genius, which may be of the highest practical value. It is a fact that becomes more and more undeniable, that most of our working miners leave school at too early an age to have their powers sufficiently developed to master the elements of science; many of them cannot write correctly, or understand the simplest terms without explanation, or work a sum in proportion; and without this amount of preparation the simplest *sound* scientific training must be lost upon them. We have, however, commenced an experiment this year, which is as yet too recent to enable us to form a judgment as to its success, which will, we trust, bring down our teaching to the level of a slightly lower capacity than that to which it has hitherto been adapted; I refer to the formation of sub-classes, of which those who have passed well in the South Kensington Examinations are teachers; the course being longer and simpler than those conducted by our official lecturer. These sub-classes are still under his superintendence, and he is instructed from time to time to test the efficiency of the work by examinations of the pupils; five of our more advanced pupils are now conducting sub-classes of this kind."

There has been some talk about attempting to establish a mining school in South Wales; and there is some stir amongst the

supporters of the mining school at Glasgow—which was allowed to die a few years since—in the hope that they may be in a position to revive it. Dr. Bryce, the President of the Philosophical Society of Glasgow, has been in correspondence with Mr. Mark Fryar, now Mining Engineer for the Indian Government, and some of the remarks made by Mr. Fryar, who was for upwards of four years the teacher in the old Glasgow school, are worthy of all attention.

"It is absolutely necessary that some arrangement be made for enabling young men to give up a portion of their work in the mines during the time of their attendance to lessons or lectures. Men or boys cannot be expected to profit much from any source of instruction after having done an ordinary day's work in a mine. I have been all my lifetime among miners, and know them well, and many a hard day's work I have done myself in mines, and I can assure you that schools of mines and scientific lectures are of no manner of use to the working miner, unless he has too the means of subsisting on about half the usual amount of labour he is expected to perform; and so physically prepare himself for mental work, and for handling the instruments used in mapping and drawing."

There is much truth in the suggestion that hard labour is not compatible with attentive study, and that those men who exhibit a thirst for knowledge should be placed in a position to acquire it, is to be desired. In considering the possibility of educating the working miner we must, however, remember that it is only with the best of their class that we shall ever have to deal. That those young and earnest men will generally succeed in placing themselves in some superior position, which will give them the required period, not of leisure, but of cessation from actual toil. Mining schools, wherever established, will only secure as satisfactory students those who have already made a mental resolve to raise themselves above their brethren. Experience has shown that mining schools in Glasgow, in Bristol, in Wigan, in Truro must be failures. It is quite as difficult for working miners to attend the classes in any one of those cities or towns, as it would be for them to attend the courses of the Royal School of Mines in London.

No system of education can be of any advantage to our mining population which is not an itinerating system. The classes must be formed in the centre of groups of mines, the instruction must be taken to the miner, since it has been proved impossible for the miner to come to the instructor.

Metallurgy.

Wolfram.—In the *Académie des Sciences*, M. La Guen, a captain of artillery, has called attention anew to the remarkable properties imparted to Bessemer steel by the addition of a small quantity of tungsten. The question was put, could wolfram, allied, as it is, to the ores of tin, be obtained at a sufficiently low price to be employed with economy? We may answer this by stating that large quantities of this mineral can be obtained at East Pool Mine in Cornwall; and that at Drake Wales, Kit Hill, and some other tin mines, it could be procured at a cheap rate, if the demand became sufficiently large to warrant its extraction.

Iron and Zinc.—Although it has long been known that iron would dissolve in molten zinc; it has not hitherto been determined whether there was any definite alloy of those metals or not. We find in Erdmann's Journal of 'Practical Chemistry,' an account of an alloy in which the metals do appear to exist in definite proportions, its formulæ being given as Fe Zn 36 ($Fe = 56$; $Zn\ 32 \cdot 75$). The physical aspect of the alloy was very different from that of zinc; it was whiter in colour and possessed a different crystalline structure; it contained $4 \cdot 6$ per cent. of iron.

Coke.—The importance of obtaining coke free from sulphur cannot, especially for iron manufacture, be over-estimated. Numerous experiments have, from time to time, been made, with a view to the use of coal in which some pyrites occur, in the manufacture of a pure coke for the blast furnace.

Some experiments have been made in France which are stated to have been remarkably successful. The coke when at a temperature of 300° Cent. was submitted to a strong current of atmospheric air strongly compressed. This current of air is said to convert the sulphur into sulphuric acid and remove it. The coke is reported to produce iron equal to that which has been made with wood charcoal.

Aluminium.—The American journals announce that Mr. A. L. Fleury, of Boston, has succeeded by a new process in smelting alumina. He mixes pure alumina with gas tar or petroleum, and forming the mixture into pellets, which are dried, they are placed in a strong retort which is lined with plumbago. Into this carburetted hydrogen gas is forced until the pressure is from 25 lbs. to 30 lbs. on the square inch. The aluminium is reduced, and remains as a spongy mass, mixed with carbon. This is remelted with metallic zinc, and the zinc being volatilized, a pure mass of aluminium remains behind. About four hours are required for reducing a hundred-weight of alumina.

Refined Iron.—Mr. Ellershausen has been carrying out some experiments, which appear to us to be new only in the method adopted, at the iron-works of Shoenberger at Pittsburg, U.S., on the conversion of crude cast-iron, as it runs from the blast furnace into wrought-iron of fine quality, by the admixture of iron ore. It has long been known that an oxide of iron will combine with and remove the carbon from pig-iron. The 'American Artizan' describes the process, which appears to consist in allowing a quantity of very finely powdered peroxide of iron to flow into boxes prepared to receive it, at the same time as the iron is allowed to flow into them from the furnace. The mass thus formed is submitted to the subsequent process of puddling, and it is said that merchant iron is produced at the first rolling, thus considerably reducing the cost.

The chemists have of late been turning their attention to the character of iron in its different varieties. Dr. Miller, of King's College, has made some useful analyses of that produced by the Heaton process. Dr. Paul has read before the Chemical Society a paper "On the Connection between the Mechanical Qualities of Malleable Iron and Steel, and the Amount of Phosphorus they contain;" while Mr. Arthur H. Elliott has a paper "On the Determination of the 'Total Carbon' in Cast Iron." Mr. J. Lowthian Bell, the well-known iron-master of Cleveland, has lectured (May 6th) before the Chemical Society "On the Chemistry of the Blast Furnace." In this lecture a very careful consideration of all the conditions under which the changes occur in the blast furnace was brought before the chemists. This union of the experience of a thoroughly practical man with the theoretical knowledge of the scientific chemist cannot fail to have its advantages.

At the present time, attention is turned with so much earnestness to the economy of coal in the production of iron and steel that we may anticipate ere long to hear of the realization of results which have hitherto been thought to be highly problematical.

Bronzes.—The production of a fine *patina* on our bronze statues instead of a coating of dust and soot is, especially in our large cities, a thing to be desired. In Poggendorff's 'Annalen' for April we find the report of a series of experiments which were made by direction of the Berlin Verein zur Beförderung des Gewerbfleisses, to examine into the causes determining the formation of this *vert antique* patina, on bronze statues.

The experiments while in progress led the observers to suppose that grease had much to do with the formation of the finest patina. Four busts were therefore placed in a part of the town which was very unfavourable. One of them was rinsed every day, with the exception of rainy days, and was painted once a month with bone

oil, which was at once rubbed off with woollen cloths. Another bust was washed daily, but not oiled. A third was cleaned daily, but oiled only twice a-year. The fourth was not at all touched. These experiments have been continued for four or five years. The result is that the bust which has been oiled once a-month possesses a dark-green patina, which is considered to be very beautiful by connoisseurs. The bust whic] has been rubbed twice a-year does not look so well. The others have no patina. The bust which has been washed regularly is the usual dull bronze colour. The other is quite dull and black. The final result of those who have been engaged in the experiments is, this use of oil justifies the hope that for the future we may retain beautifully patinated monuments, even in large towns. Where coal is the only combustible they will not be bright, but dark-green, and perhaps even black; but they will have the other beautiful property of the patina, the peculiar transparent condition of the surface.

We have recently received the following works which are directly connected with the production of those minerals which are of commercial value:—

'*Annuaire de l'Association des Ingénieurs sortis de l'Ecole de Liége.*' This gives a very complete study of the coal basin of Liege.

'*Les Houillères en* 1868,' being the Report of Amédée Burat, the Secretary to the Society of French Coal Owners. The present position of the coal trade of France is very clearly stated. Some comparisons are drawn between the modes of working the French collieries and those of Great Britain, in which the author is disposed to look upon the system adopted in his own country as superior to that which is adopted in England and Wales. The comparisons are not fairly drawn; there are doubtless isolated cases where great carelessness exists, but generally the utmost amount of care is found to prevail in our collieries.

'*The Mineralogy of Nova Scotia*' is a Report of the Provincial Government, by Dr. Henry How. It gives such a general view of the mineral resources of the Province, as will show what has actually been done in the working of its best known treasures, —coal, gold, iron, gypsum, and building stones. This report is executed with great care, and gives such statistical details as cannot fail to be of great utility to all who are in any way concerned in the mineral resources of this most interesting colony.

A recent work bearing on Metallurgy is noticed in our Chronicle of Engineering.

11. PHYSICS.

LIGHT.—The Rev. Father Secchi has made an interesting observation on the light emitted from the planet Uranus. This light, it appears, differs from that of the rest of the planets belonging to our solar system. Its spectrum exhibits broad absorption lines, so that the yellow colour is almost entirely absorbed. While it is clear that the light emitted by this planet is reflected light from our sun, it is evident that the surface of the planet modifies that light in the same manner as do coloured bodies.

Mr. Crookes has recently sent a paper to the Royal Society, in which he describes a spectrum-microscope which he has devised in order to obviate the disadvantages of the ordinary instrument. The principal features of the new apparatus are the sub-stage and the box of prisms. The former carries a sliding-plate to hold the slit and apertures, a spring stop and screws for adjusting them, and a reversed object-glass. The slit and this object-glass are about 2 inches apart, and if reflected light is passed along the axis of the instrument, the object-glass forms a very small image of the slit in front of it. The direct-vision prisms consist of three flint and two crown, fitted in a box screwed into the end of the microscope. By means of a pin they are thrown in or out of action. The object-glass screws on in front of the prism box. By taking the illumination from the sky or a white cloud, Fraünhofer's lines are visible, and by direct sunlight they are seen in great perfection; the dispersion is sufficient to cause the spectrum to cover the whole field, and the achromatism of the lenses being nearly perfect, the lines from B to G are practically in the same focus. When the light is good, the appearance of the spectrum, and the power of grasping faint lines, are greatly improved by dividing the light with a Wenham prism, and using both eyes; whilst the stereoscopic effect thereby communicated to some absorption and interference spectra, throws a new light on the phenomena.

By using a spirit-lamp instead of the illuminating lamp, the instrument answers admirably for examining flame spectra. The characteristic yellow, crimson, or green lines are seen beautifully sharp, on introducing sodium, lithium, or thallium into the flame.

By means of this spectrum-microscope Mr. Crookes has observed some curious optical phenomena of opals.

If an opal which emits a fine broad crimson light is held in front of the slit of a spectroscope, or spectrum-microscope, at the proper angle, and the source of light is moved so as to shine into the spectrum apparatus through the opal, the appearance is observed of a luminous spectrum with a jet black absorption band in the red.

From these and other experiments it has been found that those

parts of the opal which emit red, yellow, green, or blue light are opaque to light of the same refrangibility which they emit. The appearances of some opals examined in this way are very striking. In the next number of the 'Quarterly Journal of Science' Mr. Crookes will describe these and other kindred phenomena more fully, but we may briefly allude to the following curious spectra which have been observed:—

Some opals show a simple black band in the red, which when in focus has a spiral structure. Examined with both eyes, it bears a resemblance to a twisted column.

In another opal, which gives an irregular line in the orange, the spiral structure is shown in a marked manner, the different depths and distances standing well out; upon carrying the opal slowly from left to right, the line is seen to revolve and roll over, altering its shape and its position in the spectrum. It is not easy to retain the conviction that one is looking merely at an absorption band in the spectrum, and not at a solid body possessing dimensions, and in actual motion. Other opals show an absorption band travelling along the spectrum, almost from one end to the other, as the opal is moved sideways.

M. Soret, in consequence of Professor Tyndall's note "On the Clouds," has examined, by means of the polariscope, the beautiful blue colour exhibited by many parts of the Lake of Geneva, and he states that this colour is due to the presence of solid particles in the water, of the same specific gravity as that fluid; but he does not say what these particles are, nor what size or shape they have; promising, however, further researches.

In order to answer the often-doubted fact of the decomposition of carbonic acid under the influence of light, and the separation of oxygen by the leaves of plants, Boussingault has introduced into mixtures of carbonic acid gas and hydrogen, and the former gas and nitrogen, first a clean stick of phosphorus; as long as no oxygen is present, this element does not undergo slow combustion, thereby giving off vapours; but as soon as a green leaf of any plant was carefully brought into the gaseous mixtures standing over mercury, the slow combustion of the phosphorus began, owing to the decomposition of the carbonic acid and formation of oxygen; this action takes place also in diffused daylight, but not during twilight; leaves wherein the chlorophyl is not fully developed do not act in this manner.

It is a well-known fact that, even independent of the effects of rain and wind, glass, even of good quality, is affected by sunlight. The late Dr. Faraday made some observations concerning this subject, and found that violet-coloured glass became deeper and more intensely coloured than it originally was, after

having been exposed to direct sunlight for eight months. M. Graffield, of Botson, U.S., who has been for more than twenty years in the wholesale glass trade, and is at the same time a good observer, has recently sent to the Photographic Society of Marseilles a series of the results of his researches and observations on this subject, in which he comes to the conclusion (which is especially important to photographers) that glass is even sensibly affected after one single day's exposure to the sun's rays, and that all glass, without exception, including that used for optical purposes, is more or less acted upon, even when made from the best materials and by most experienced workmen; greenish glass seems to become the least affected. The author has sent to Marseilles a series of photographs representing the tinge and changes produced in divers varieties and kinds of glass after exposing them to sunlight.

Many of our readers have had the opportunity of noticing that bottles, especially if made of white glass, containing disulphide of carbon often become lined, if exposed for any length of time to direct sunlight, with a coating strongly adhering to the glass. M. Loew has experimented on this substance, by enclosing the disulphide in sealed glass tubes previously moistened with water, which has the effect of lessening the adhesiveness of the brownish coating. On opening the sealed tubes after a few months' exposure to sunlight, the water was observed to have an acid reaction, due to the formation of some formic acid. The solid substance alluded to is insoluble in alcohol, chloroform, ether, and disulphide of carbon, but soluble in a boiling solution of caustic potassa, becoming, however, at the same time decomposed. It has the composition of sesquisulphide of carbon, and on being submitted to distillation is decomposed, yielding sulphur and carbon. The disulphide of carbon from which this substance is deposited contains sulphur in solution, although it was perfectly pure previous to exposure to sunlight.

When freshly-precipitated chloride of silver (best obtained by decomposing a soluble silver salt with chlorine-water) is placed in a white-glass tube about 15 inches in length, and exposed to the action of direct sunlight, it will be observed that the chloride of silver remains quite white as long as the solution of chlorine-water retains its greenish-yellow colour; but as soon as that colour has vanished, the chloride of silver begins to decompose water under the influence of the direct rays of sunlight; the chloride gradually blackens, and after a shorter or longer duration of time, the whole quantity will have become black, especially if care be taken to shake the tube now and then, so as to expose the whole mass to the light. When the tube is afterwards placed in a dark place, entirely excluded from daylight, the black colour of the chloride of silver again disappears gradually, and the chloride becomes white. This

experiment can be repeated over and over again with the same tube. The bromide, and probably also the cyanide of silver, behave in the same manner; the iodide of silver blackens only after having been rendered sensitive to light by pyrogallic acid.

Dr. Thudicum has recently published some investigations on Luteine. By luteine Dr. Thudicum understands a yellow crystalline substance occurring in va ious parts of animals and plants, as, for instance, the *corpora lutea* of ovaries, serum of blood, yolks of eggs, in seeds, as maize (Indian corn), in annatto, in carrots, and the stamina and petals of a great many flowers. Luteine is easily soluble in alcohol, ether, and chloroform; insoluble in water. These solutions are yellow; but that in chloroform, when concentrated, has an orange-red colour. The spectrum of its solutions is distinguished by great brilliancy of the red, yellow, and green part, and by three absorption bands, which are situated in the blue, indigo, and violet part of the spectrum. The crystals of luteine are apparently rhombic plates, of which two or more are always superposed in a curious manner. The crystals are microscopic yellow when thin, orange to red when thick, and have no resemblance to any other known animal or vegetable substance. Luteine combines with few substances, mercury-acetate being perhaps the only reagent by which it is immediately and completely precipitated as a yellow deposit; mercury-nitrate produces a yellow precipitate, which on standing becomes white. Nitric acid, poured over the crystals, produces a blue colour, which immediately passes into yellow. The blue is not produced when nitric acid is added to either the alcoholic, ethereal, or chloroformic solution of luteine, but appears with the acetic-acid solution, and disappears again rapidly. Luteine has great affinity for fatty matters and for albumen.

The Paris correspondent of the 'British Journal of Photography' reports that the oxyhydrogen-zirconia light has been such a success at the Tuileries, having been worked without interruption since the 21st of January, that the Emperor has ordered measures to be taken to render that mode of illumination permanent in front of his palace. In connection with this fact, we may mention that M. Tessié de Mothay has had the Order of Chevalier of the Legion of Honour bestowed upon him. The learned Abbé Moigno, while referring to this subject in '*Les Mondes*,' says, "Our readers will undoubtedly hear with pleasure that the production of oxygen in a cheap manner from manganate of potassa, and that of pure hydrogen, by means of a hydrocarbon fuel on the large scale, have become a decided success; that moreover, the reduction of the earths baryta, magnesia, and alumina to the metals barium, magnesium, and aluminium, by means of hydrogen under high pressure and a very high temperature, is successfully carried out; while lastly M. Caron

has succeeded in obtaining, by means of great perseverance, zircon-magnesia cones, which, instead of being very breakable and only lasting for a few nights, are fit for use for any length of time."

Mr. D. Winstanley has described an apparatus for obtaining a light from the combustion of disulphide of carbon. It consists of a water-bath, heated by a Bunsen gas-burner. Within the water-bath is placed a vessel to hold disulphide of carbon. The outer and inner vessels are firmly soldered together, and proper arrangements are made to enable the experimenter to pour water in the outer vessel, which is also provided with a neck to hold a thermometer, serving to indicate when the temperature at which the disulphide of carbon contained in the inner vessel boils. The inner vessel is provided with a neck, closed by a well-fitting cap when the apparatus is in use, for the introduction of the fluid disulphide of carbon. Besides this, there is soldered to the inner vessel a gas-pipe of small bore, which pipe projects at a convenient height above the outer vessel. To this pipe is soldered and connected at right angles another pipe provided with a stopcock, and further connected, by means of elastic tubing, with a gas-holder containing oxygen gas made from chlorate of potash. After the application of gas-flame beneath the water-bath, the thermometer is watched until it indicates that the vapour of the bisulphide of carbon is issuing from the burner (from the gas-pipe connected with the inner vessel); the heat is allowed to continue beneath the water-bath until the flame reaches the flaring point, when it is lessened almost to extinction. The oxygen gas is then cautiously introduced, upon which the flame at once diminishes in size and increases greatly in brilliancy. This light is proposed for use in photography, on account of its great actinism: as a source of intense heat it may also perhaps be recommended.

Heat.—While engaged in other studies on geology in the southern parts of France, M. Andouin found that between Tarascon and Antibes there exists a very valuable and extensive bed of *bauxite* (hydrate of alumina), which is occasionally applied for the manufacture of sulphate of alumina. This material has been applied at his suggestion for the manufacture of crucibles and fire-bricks; and on having been tested in comparison with the best products of the kind from France, England, and Germany, it was found that even best fire-bricks might be melted in bauxite-made crucibles, heated by mineral oils and a blast.

In reference to the well-established fact that water, after having been deprived of air as much as possible, either does not boil at all when heated, or does so with violent sudden starts and concussions,

some experiments have been made by Kremers, who observed that, in order to assist in expelling air from water, the addition of spirits of wine, in the proportion of one part of the latter to three of the former, is very useful. He cautions against a danger which exists when such a mixture is heated too rapidly; since it is very apt to boil over, especially after a portion of the spirit has evaporated. It is rather curious that, though both the water and spirits of wine employed were pure, the mixture when boiling should assume a greenish-yellow hue, which disappears again on cooling. The boiling-point of the fluid easily becomes as high as 109°. As a result of a large number of experiments, the author finds that water, as fully deprived of air as possible, may be heated as high as from 180° to 200° C., without boiling permanently.

M. Debray has investigated the action of heat upon the peroxide salts of iron. In a large portion of distilled water a few drops of a *neutral* solution of chloride of iron are poured, care being taken not to apply so much of the salt that its colour is imparted to the water; on heating the liquid gradually up to, and above, 70° C., it becomes perceptibly brown-coloured. When this moment has arrived, the water no longer contains chloride of iron, but instead a mixture of free hydrochloric acid and free peroxide of iron; the limpidity of the fluid is not, however, at all impaired. In order to prove this, it is only requisite to pour into the fluid a solution of common salt, whereby the static equilibrium of the liquid is disturbed, and the oxide of iron precipitated. When the experiment is made in sealed tubes, and the latter heated to between 200° and 300° C., crystalline oxide of iron is precipitated.

A new freezing mixture, which appears to be of considerable interest, has been described by Mr. Galletly. When citric acid and crystallized carbonate of soda, in powder, are stirred together, the mass gets into a pasty state, and in a short time becomes quite liquid. If equivalent proportions of the substances are used, the temperature falls from 60° F. to −8° F. The mixture for a time is full of air-bubbles, but soon becomes a clear, dense, syrupy fluid. The fluid obtained by mixing the powders becomes solid in a day or two standing in a corked jar. The solid mass has the appearance of set plaster of Paris or damp chalk. The addition of a very little water appears to prevent this setting into a solid mass; but the chalky-looking citrate lies a long time in cold water without being dissolved.

Dr. H. Fleck, of Dresden, has instituted a series of experiments with a view to obtain a non-poisonous paste for application to lucifer-matches. He ascertained by some preliminary experiments that sodium, when minutely divided along with explosive

substances, becomes highly inflammable when simply moistened with water. A mixture was made of

0·5	grammes of	sodium,
66·0	„	nitrate of potash,
36·5	„	sulphide of antimony.

Provided that during its manufacture this mixture is kept thoroughly dry, it has been found to answer admirably well. According to several accounts from Germany, this plan of substituting sodium for phosphorus has been favourably taken up by some of the largest leading manufacturers of lucifer and fusee matches. There is said to be not the least danger in the transport.

It is well known that various accidents occur from fire caused by persons carelessly throwing down matches, which they believe to be harmless because the flame has been extinguished, but which, in reality, are highly dangerous, and quite capable of communicating fire to any light dry material, in consequence of the wood-splint being at a red heat, although not actually in flame. It appears from the 'Scientific American' that it has been proposed, in order to prevent this, to saturate the splints, previously to their being dipped, with a solution of some chemical salt which has the property of preventing the wood from remaining at a red heat after the flame has been extinguished without being in any way detrimental to the inflammable nature of the splint, and thus to prevent the possibility of accident from the dropping of the match after the extinction of the flame, but while the splint is still at a red heat. The substance which it is proposed to employ is alum, though other salts have the same property. The matches before being dipped are to be immersed in a strong solution of alum, or other salt with a similar action, until they are saturated; they are then to be dried and tipped with the ordinary composition. Matches, so treated, are said to ignite, and burn with flame as long and readily as other matches; but the instant the flame is blown out, the match becomes black and perfectly harmless.

Electricity.—By far the most gigantic electrical instrument ever made has just been fitted up at the Royal Polytechnic Institution. This is the large induction-coil, which has been made by Mr. Apps. It is 10 feet long and 2 feet in diameter. The core of soft iron weighs 123 lbs., and consists of wires each 5 feet long and 0·0625 in diameter. The primary coil weighs 145 lbs., and is composed of 3770 yards of copper wire. The secondary wire is 150 miles in length, and 0·015 inch in diameter. The galvanic current for the primary coil is supplied by 40 of Bunsen's cells. It is capable of producing a spark 29 inches long, and the flash will perforate plate-glass 5 inches thick. This huge and powerful coil

will not only be valuable to Professor Pepper to illustrate the wonders of electricity to the general public, but it has already been placed by him at the disposal of Dr. Richardson and other scientific men as a means of promoting scientific research.

Dr. Sarrazin has noticed some hitherto unknown phenomena of phosphorescence. As soon as pure oxygen is reduced to a pressure of only two millimetres or less, it becomes exceedingly luminous under the influence of electricity. No other known gas is possessed of this property. All compound gases which contain oxygen become also luminous, and most so the protoxide of nitrogen. The doctor has found that the cause of this phosphorescence is due to the formation of ozone, since it does not take place when, previous to passing an electric current through the gas, powdered metallic silver has been introduced into the space containing the gas; in this case the silver becomes rapidly oxidized.

While engaged in studying the part which sulphuric acid plays in these phenomena, Dr. Sarrazin found that when a small quantity of this acid, which is considered non-volatile at ordinary temperatures, was confined along with nitrogen gas, for instance, in a gas jar, and an electric current passed through, a very intense luminosity was caused, notwithstanding nitrogen is not by itself rendered luminous under these conditions. The author found that there was decomposition of sulphuric acid, with formation of ozone, and that the phenomena ceased when powdered silver was introduced.

Mr. Freidel has quite recently discovered that silicated hydrogen gas is entirely decomposed by the electric spark, giving rise in the endiometer to a shower of amorphous silicium of a brown colour.

A phono-electroscope has lately been described by Mr. Edwin Smith, M.A., for the purpose of illustrating the heating power of the voltaic current. It consists of a rectangular wooden box, 10 inches by 5, two steel or platinum wires stretched from end to end, a small spindle carrying two quill plectra, and an eccentric wheel for making and breaking the current through one of the wires. The wheel turns under a brass spring, which plays upon a button. The spring is connected with one electrode of the battery, the button with the wire nearest to it, and this wire with the other electrode. To exhibit the use of the instrument: first, tighten the wires by means of milled-headed screws, to unison, to about the pitch of middle C; then turn the spindle so as to sound the two notes in succession *before* the eccentric wheel makes the circuit. After these have unison, turn the spindle a little more; the circuit is made by wheel and spring, and presently the plectra are allowed to play a second time on the wires, which now sound, with an interval of a tone or more, according to the quantity of electricity which has

passed through one of them. By regulating the time between the instant when the wires sound in unison and the instant when they sound again, and noticing the musical interval caused by one of them becoming flat, we have an audible measure of the expansion of the connected wire, of the temperature to which it has been raised, and of the quantity of electricity which has traversed it to produce that effect. By continuing the movement, the interval between the notes will increase, and at last the wire operated on will become too slack to sound at all. If connection with the battery be now broken, and the heated wire be allowed to cool, its note will be heard to rise by degrees to its original pitch. With a single pair of plates, the phono-electroscope answers well. The experiment is a striking one in a lecture-room, very instructive, and easily managed.

According to Böttger, the metal antimony may replace graphite in galvanic batteries. He finds the following arrangement preferable, as regards force and durability, to either Daniell, Minotto, or Leblanche's batteries. A cylinder of amalgamated zinc is placed in a concentrated solution of equal parts of common salt and sulphate of magnesia; the antimony is placed in a porous cell filled with dilute sulphuric acid.

Mr. Gore, F.R.S., whilst making some experiments on heating strained iron to redness by means of voltaic electricty, observed that, on disconnecting the battery and allowing the wire to cool, during the process of cooling the wire suddenly elongated, and then gradually shortened until it became quite cold. The amount of elongation of the wire during the momentary molecular change was usually about 1-240th part of the length of the heated wire; the molecular change evidently includes a diminution of cohesion at a particular temperature during the process of cooling, and it is interesting to notice that at the same temperature during the heating process no such loss of cohesion, nor any increase of cohesion takes place; a certain temperature and strain are therefore not alone sufficient to produce it, but the condition of cooling must also be included.

M. Alvergniat calls attention to the fact, that by simply rubbing one of Geissler's tubes with the dry hand or a piece of silk, it exhibits the same phenomena of luminosity as if induced by electricity; the phosphorescence is, however, weak, but may be increased when within the tube substances are deposited which may become phosphorescent under the influence of electricity; when a tube so arranged is quickly rubbed, it becomes within a few moments sufficiently luminous to serve as a faint light to see in a dark room.

12. ZOOLOGY—ANIMAL MORPHOLOGY AND PHYSIOLOGY; AND RECENT LITERATURE.

Morphology.

New Views on the Homologies of the Suspensorium.—The advanced school of osteologists—that is to say, those who reject the vertebral theory of the skull—originated by Oken and Goethe and developed by Carus, have been in the habit of pointing to the *ossicula auditûs* as the homologues of the quadrate and articular pieces, the incus being regarded as the homologue of the former, the malleus as that of the latter. The relations of the chorda tympani to these bones, though said to support this interpretation, did not really do so; and many powerful arguments were urged against it by Professor Peters of Berlin, Professor Humphry of Cambridge, and others. Professor Huxley, who is chiefly responsible for the view in this country, has re-examined the matter, and has been led to a much more satisfactory conclusion, especially from the study of that very remarkable lizard, the *Hatteria, rhyncocephalus,* or *Sphenodon* of New Zealand. Instead of now regarding the incus as the homologue of the quadrate, he considers it to form part of the second visceral arch, and to be represented in Birds and Reptiles by a ligament or a cartilage connected with the stapes. He regards the malleus as the representative of the quadrate, the articulare of the lower Vertebrata not being represented by bone in the Mammalia. In Fishes he considers the incus to be represented by the "hyomandibular" or "suspensorial" element. Mr. Parker, the author of the very splendid volume on the Shoulder Girdle issued last year by the Ray Society, has been examining this question of the lower jaw in Amphibians, and his researches lead him to agree with Professor Huxley's conclusions.

Muscular Homologies.—There are some important papers relating to this subject to be chronicled. Professor Rolleston, in a paper read to the Linnean Society, discusses the homology of certain muscles connected with the shoulder-joint; and in the Transactions of the same Society are very well-illustrated memoirs on the limb-muscles of the Six-banded Armadillo, and of the "Ard Vaak," or Cape Ant-eater. These three papers emanate from the Oxford Anatomical Laboratories. Professor Humphry has two papers on similar subjects (Myology of *Pteropus*, and of the Leg and Forearm) in the 'Journal of Anatomy;' whilst Dr. Macalister, of Dublin, has a third, on the Pronator Muscles in Vertebrate Animals. The general result of these papers is greatly to add to our knowledge of the muscular structures of Mammalia, and especially to give definite views on the serial homologies of the muscles of the fore and hind extremities.

The Vielle of the Seychelles.—This enormous fish, the *Batrachus gigas*, is occasionally caught by the fishermen of the above islands. Mr. Swinburne Ward, a resident in the Seychelles, writes that he has made repeated endeavours to procure a specimen to send to Europe, but it is exceedingly difficult so to do. The fishermen are sometimes obliged to cut the lines when a Vielle has been hooked, and on one occasion Mr. Ward was disappointed by the escape of a monster just as he had brought him to the surface. One has been known in the harbour for the last six years, lurking in a deep hole, as appears to be the habit of the species; and he refuses all snares and baits which are contrived to capture him. A head was sent recently to London by Mr. Ward, of a very large specimen, the greater part of which had been damaged; and he is now making continued efforts to obtain a good specimen. The fish is often as much as seventeen feet in length.

The Zandr, or Pike-Perch, is a fish resembling in external appearance both pike and perch, which is common in Eastern Germany, and is much eaten in Berlin, but is not known to the west of the Elbe. Mr. Frank Buckland has been making endeavours to procure specimens for naturalization in this country; and a dealer who recently went to Berlin to obtain specimens of the *Silurus glanis* for the reservoirs of a gentleman residing in Oxfordshire, brought over with him some specimens of this interesting fish. Herr Brockhardt has promised to send Mr. Buckland next spring a living zande of 11 or 12 lbs. weight, and also young zandes. The fish inhabits the lake-like expansions of the Naffel, Spree, and other rivers in North Germany, and is hence rather a lacustrine than a fluviatile species.

The Green Leech.—*Trocheta viridis* was first recorded as a British species some years ago by Dr. Gray, who had a specimen sent to him which was obtained in a very strange place, *viz.* Regent's Park. Mr. Henry Lee has lately rediscovered the species, and Mr. Pryor, of Trinity College, Cambridge, has also found it at Horsham in Surrey. The green colour was supposed by some persons to be possibly due to chlorophyl. Mr. Lankester, whose observations with the spectroscope first proved the presence of chlorophyl in the river Sponge, in Hydra viridis, and in a green worm (*Mesostomum*), finds upon spectroscopic examination that the green colour of *Trocheta* is not due to chlorophyl, but to a distinct green colouring matter soluble in alcohol, which also occurs in some marine annelids.

Impregnation of Balani.—In a recent Chronicle we noticed Fritz Müller's observations on South American Barnacles, which led him to believe that these animals are not only hermaphrodite, but capable of impregnating neighbouring individuals: and thus possibly in some cases a crossing of species might arise, which he

was led to expect from the occurrence of forms apparently intermediate between species which live in adjoining habitats. Mr. R. Bishop, of Plymouth, records in the 'Annals' that he has seen copulation take place in a group of Barnacles which he was keeping in an aquarium. Great activity and excitement was exhibited by all the specimens, and they continually threw out a long tongue-like organ which penetrated adjacent individuals, and was clearly in his opinion an act of impregnation.

PHYSIOLOGY.

Action of Anæsthetics on the Blood.—Dr. J. H. McQuillen, of Philadelphia, has made a microscopical examination of the blood-corpuscles of animals killed by chloroform and by nitrous oxide, with a view of testing the assertion of Dr. Sansom, that chloroform destroys the red corpuscles. He finds that it undoubtedly does so when brought into contact with the blood after it has been drawn and placed on a glass slip, but that it certainly has no such effect in the body, nor has nitrous oxide, as he fully proves by experiment. Dr. McQuillen adds to this, that he considers undue prominence has been given by physiologists to the blood-corpuscles as *the* carriers of oxygen to the tissues, and carbonic acid gas to the lungs, and that it is reasonable to infer that the liquor sanguinis is engaged in this operation. But to what physiologists does he refer? Surely he cannot be acquainted with the modern researches and conclusions on this matter, for it is universally admitted, as the result of experiment, that a large part of the carbonic acid of the blood is held by the serum; indeed it has been a question if any is held by the corpuscles at all. Alexander Schmidt in a recent paper has shown that a variable amount is present in the corpuscles, whilst Sertoli and Zuntz have also been at work on the matter. The latter physiologist believes that a portion of the CO_2 of the blood is combined with carbonate of sodium and phosphate of sodium in the serum; the rest is in part merely dissolved, and in part retained, with a combination of potash and hæmoglobin in the blood-corpuscles.

Insusceptibility of Pigeons to Opium-poisoning.—Dr. Weir Michell, an able American physiologist, having occasion to produce sleep in pigeons, administered to them doses of various preparations of opium, but failed to produce the desired effect. Astonished at the failure, he made experiments with a view of seeing how much opium was required to kill these birds. He writes, "Pigeon took 80 drops of black-drop internally; no effect except a tendency to keep quiet; no signs of stupor; no change of pupils; feathers ruffled, as is common with these birds when sick from any cause. Pigeon received 42 drops of black-drop under skin of groin.

Symptoms the same as in the last case. Neither of them slept at all, and both were well the next day. Pigeon received under skin, in three localities in all, two grains of sulphate of morphia dissolved in water slightly acidulated with acetic acid. No effects were seen other than those described in the former cases. Pigeon took internally three grains of sulphate of morphia dissolved; recovery without notable symptoms. Pigeon took at 8.30 A.M. 272 drops of black-drop; he retained it during an hour, but at twelve was found to have vomited an unknown amount of it, by estimate at least half; recovered after remaining all day quiet in the corner of his cage, not asleep, and capable of being easily aroused, and then able to execute every usual movement, as flying, walking, and the like. The final experiment seems to me decisive. To a large pigeon, which within the two preceding days had swallowed 42 drops of black-drop, I gave, between two P.M. and six o'clock, 21 grains of powdered opium in soft pills of three grains each. Except the usual tendency to remain quiet, none of the common evidences of opium-poisoning appeared, and the pigeon was well and active next day."

Cause of Death when the Skin is covered with Varnish.—A writer in the 'Journal of Anatomy' observes that some persons have supposed that when an animal dies from the effects of having its skin covered with varnish, its death must be ascribed to the retention of deleterious matters given off by the skin. Edenhuizen thought that the noxious matter is volatile alkali. Gerlach and others thought that death was due to suppression of the respiratory functions of the skin; while Valentine had, on the other hand, shown that the morbid symptoms manifested by a varnished animal disappear if the animal be placed in a higher temperature, thereby leading to the notion that death in such a case results from increased loss of heat. Laschkewitsch, of St. Petersburg, has by recent researches confirmed the truth of the last-mentioned theory. A varnished animal, when surrounded by cotton-wadding, suffered no harm, though it died when the wadding was removed. He found the blood-vessels much dilated below the varnish; he supposes that the dilatation of cutaneous vessels favours the loss of heat by the skin. He has found that the volatile alkali spoken of by Edenhuizen results from the decomposition of hair and epidermis. He further disproved Gerlach's view that asphyxia is the cause of death, by placing an animal in an atmosphere of hydrogen, taking care to cover the animal's mouth with an elastic funnel communicating with the external atmosphere. The animal lived in this medium for six hours without suffering any deleterious effects.

Miscellaneous Literature, &c.

Prof. Huxley's New Book.--A book on the classification of animals by Prof. Huxley has just been published, and must be of great value to those reading for examinations, as well as to students and teachers. It is an extension of the lectures published in a former volume, which also included lectures on the skull. The orders as well as the larger groups of the animal kingdom and the *principles* of classification are discussed in this book, which is undoubtedly the most advanced and most trustworthy manual of the outlines of comparative anatomy yet published.

The Journal of Anatomy.—We desire cordially to recommend this excellent journal, published half-yearly, to such of our readers as are interested in the advancement of physiology and anatomy. Professors Humphry and Turner are ably carrying on their undertaking, begun in 1867, but we can well believe that a more extended circulation would be to the advantage of all parties concerned. The reports on the progress of anatomy by Professor Turner, and on various departments of physiology by Drs. Gamgee, Rutherford, and Fraser of Edinburgh, and Dr. Moore of Dublin, are among the most useful and complete records of biological literature that are published in any language.

Quarterly List of Publications received for Review.

1. British Conchology; or, an Account of the Mollusca which now Inhabit the British Isles and the surrounding Seas. Vol. V. Marine Shells, and Naked Mollusca to the end of the Gastropoda, the Pteropoda, and Cephalopoda, &c. (conclusion of the work). By John Gwyn Jeffreys, F.R.S., &c. *Van Voorst.*
2. A History of the British Hydroid Zoophytes. By Thomas Hincks, B.A. 2 vols. *Plates.* *Van Voorst.*
3. A Practical Treatise on Metallurgy, adapted from the last German Edition of Professor Kerl's Metallurgy. By Wm. Crookes, F.R.S., and Ernst Röhrig, Ph.D. Vol. II. Copper—Iron. *With* 273 *Wood Engravings.* *Longmans.*
4. Sound and Colour: their Relations, Analogies, and Harmonics. By J. D. Macdonald, M.D., F.R.S. *Longmans.*
5. On the Chemical Changes of Carbon. By Wm. Odling, M.B., F.R.S. (A Course of Lectures.) Reprinted from the 'Chemical News.' With Notes by W. Crookes, F.R.S. *Longmans.*
6. On the Principles of Pure and Applied Calculation, and Application of Mathematical Principles to Theories of the Physical Forces. By Rev. James Challis, M.A., F.R.S., &c. *Cambridge: Deighton, Bell, & Co. London: Bell & Daldy.*
7. Iron and Steel. By Knut Styffe, Director of the Royal Technological Institute at Stockholm. Translated by C. P. Sandberg, with a Preface by John Percy, F.R.S. 9 *Lithographic Plates.* *John Murray.*
8. Habit and Intelligence. By Joseph John Murphy. 2 vols. *Macmillan & Co.*
9. On Going to Sleep. By Charles H. Moore. *R. Hardwicke.*
10. Croonian Lectures on Matter and Force. By Dr. Henry Bence Jones, F.R.S. *J. Churchill & Sons.*
11. Reliquiæ Aquitanicæ. Part VIII. *Bailliere.*
12. Die Chemie der Jetztzeit. C. W. Blomstrand, Prof. an der Universitât zu Lund. *Heidelberg: C. Wintersche Buchhandlung.*
13. La Storia Antica, Restituita a Verita e Raffrontrata alla Moderna. Dal Commendatore Negri Cristoforo. *Torina: Stamperia dell' Unione Tipografico-Editrice.*
14. Spectrum Analysis. By Henry E. Roscoe. *With coloured Plates and Illustrations.* *Macmillan & Co.*

15. Cyclopædic Science Simplified. By J. H. Pepper. *With six hundred Illustrations.* *Warne & Co.*
16. Sound: a Course of Eight Lectures, delivered at the Royal Institution of Great Britain. By John Tyndall, LL.D. F.R.S. &c. *Longmans & Co.*

PAMPHLETS AND PERIODICALS.

Discoveries in Science by the Medical Philosopher. By Sir G. Duncan Gibb, &c. *H. K. Lewis.*

On the Conditions of the Metallic Currency of the United Kingdom, with reference to the Question of International Coinage. By W. Stanley Jevons, M.A.

On the Structure and Affinities of Parnassia palustris, &c. By Alf. W. Bennett, M.A., B.Sc.

London Water Supply. By H. H. Fulton, C.E.

On the Action of Nitrites on Blood. By Professor Gamgee.

Reports of the Mining Surveyors and Registrars. *Victoria.*

A Problem for Trisecting an Angle geometrically, &c. By Sampson Sandys.

Statistics of New Zealand.

The Mineralogy of Nova Scotia. By Henry How, D.C.L.

Report on the Culture of the Japanese Silkworm in England. By Alexander Wallace, M.D., &c.

Of Geological Dynamics. By Sir William Thomson, LL.D. F.R.S. Reprinted from the 'Transactions of the Geological Society of Glasgow.' Vol. III. Part 2.

Colorado: United States, America; its History, Geography, and Mining. By R. O. Old. *London.*

Nekrosozoic Process for the Preservation or Embalming of the Human Body. Reports of Dr. Francis Delafield, Professor James R. Wood, Professor R. Ogden Doremus, Professor A. Flint, jun. *Garstin & Co.*

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Quarterly Notes on Books. *Longmans.*

Revue Bibliographique Universelle,* June, 1869. *Paris.*

* This Review contains, besides Notices of Books in all languages, a list of all important works in Theology, Jurisprudence, the Arts and Sciences, Philosophy, Politics, Education, Industry, Finance, and Commerce, the Fine Arts, Belles Lettres, Novels, History, &c.; also the contents of all noteworthy periodicals published in the French, German, English, Dutch, Italian, Polish, Russian, &c., languages.

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Van Nostrand's Eclectic Engineering. No. VI. *New York.*
The American Naturalist, June, 1869. *Salem, Mass.*
The Educational Gazette.
The Geological Magazine.
Scientific Opinion. Part VII.
The Popular Science Review.
The Westminster Review.
The Chicago Medical Times. Vol. I. No. 3.

PROCEEDINGS OF LEARNED SOCIETIES, &c.

Third Annual Report of the Aëronautical Society of Great Britain. President: The Duke of Argyll. Hon. Sec.: F. W. Brearey.

The Journal of the Historical and Archæological Association of Ireland.

Transactions of the Geological Society of Glasgow.

Proceedings of the Bristol Naturalists' Society.

" " Miners' Association of Cornwall and Devonshire. By R. Hunt, F.R.S., Hon. Gen. Sec.

Report of the Rugby School Natural History Society.

Bolletina della Societá Geografica Italiana (with President's Address). *Firenze*: *Guiseppe Civelli.*

Journal of the Ethnological Society of London. Edited by Professor Huxley, F.R.S., President. Hon. Sec., Lionel J. Beale, M.R.C.S.

Address at the Anniversary Meeting of the Royal Geographical Society, May 24, 1869. By Sir Roderick Impey Murchison.

Proceedings of the Royal Institution.

" " Royal Society.

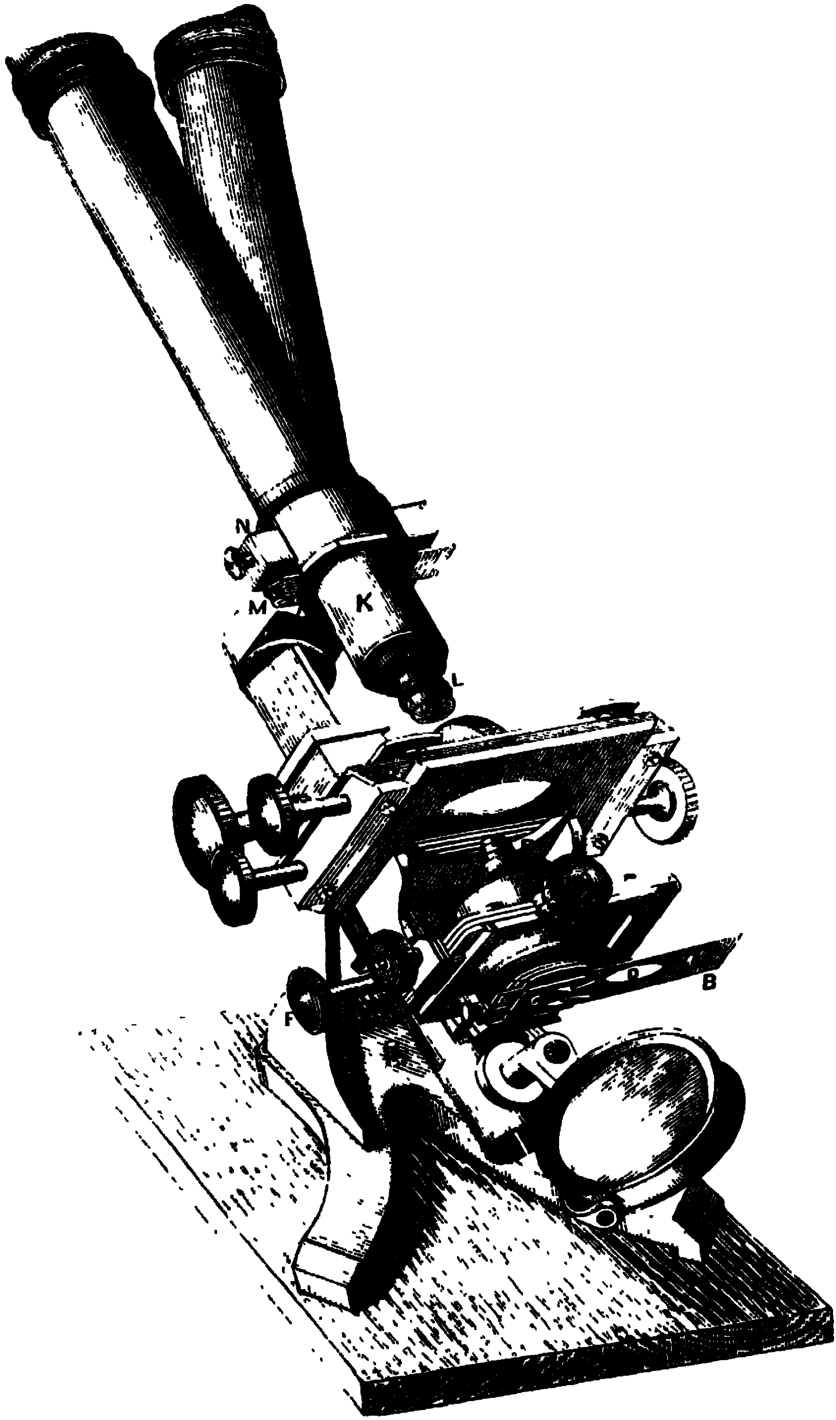
" " Royal Astronomical Society.

" " Zoological Society.

" " Bath Natural History and Antiquarian Field Club. No. 3.

In the present Number (XXIII.) of this Journal will be found, besides numerous Short Notices of Books, Pamphlets, and Essays, Reviews of the following recent works on Scientific subjects:—

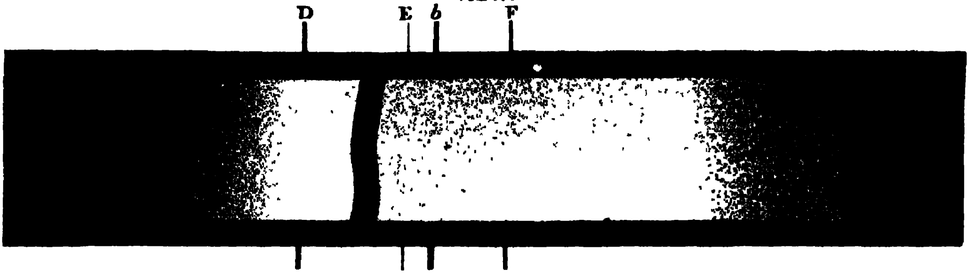
* In Chronicle of Archæology. † In Meteorological Chronicle.



The Binocular Spectrum Microscope,

To illustrate Mr. Crookes's article on the Spectral Phenomena of Opals.

No. 1.



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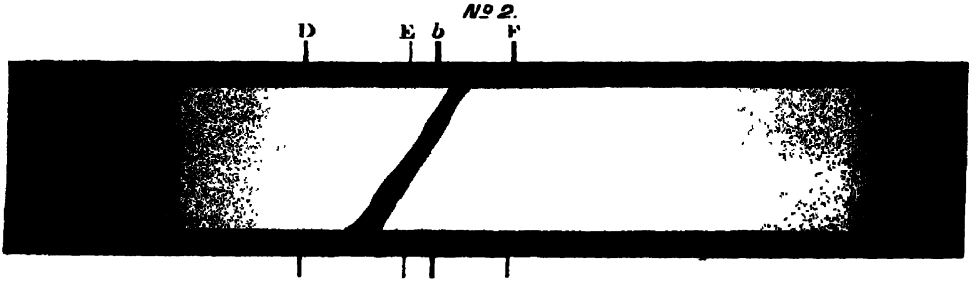

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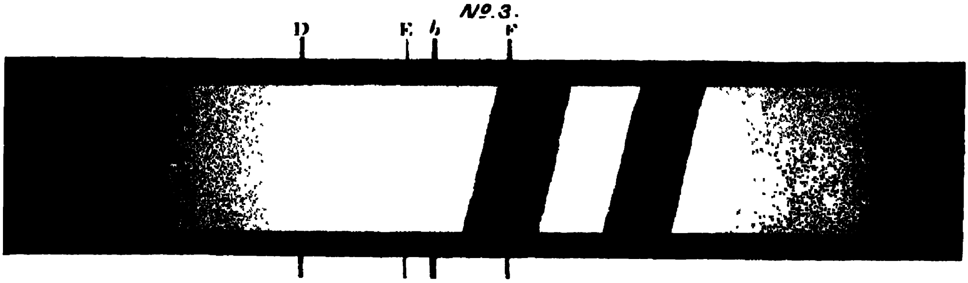

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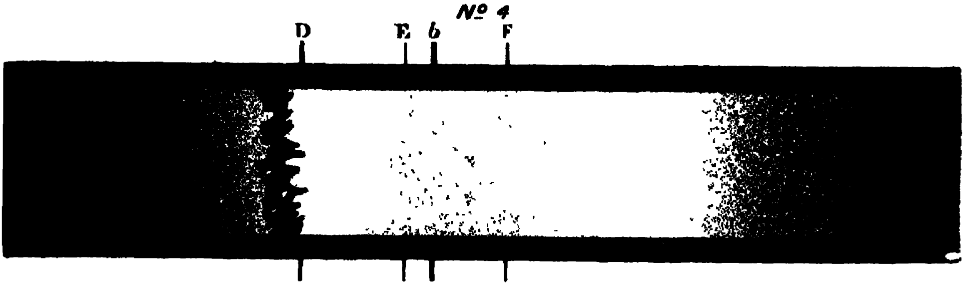

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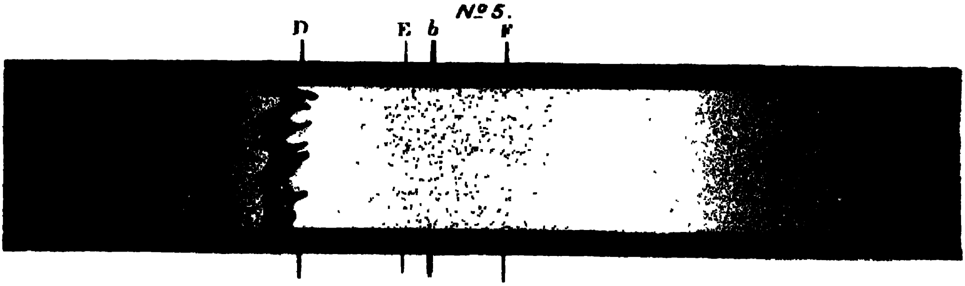


SPECTRAL PHENOMENA OF OPALS

By William Crookes F.R.S. &c.

THE QUARTERLY

JOURNAL OF SCIENCE.

OCTOBER, 1869.

I. ON THE SPECTRAL PHENOMENA OF OPALS.

By WILLIAM CROOKES, F.R.S., &c.

A FEW months ago* the writer described a new form of spectrum microscope, in which some of the disadvantages possessed by the old form are removed. The new spectrum apparatus consists of two parts, which are readily attached to an ordinary single or binocular microscope, and when attached they can be thrown in or out of adjustment by a touch of the finger, and may readily be used in conjunction with the polariscope or dichroscope; object-glasses of high or low power can be used, although the appearances are more striking with a power of ½-inch focus or longer; and an object as small as a single corpuscle of blood can be examined, and its spectrum observed.

The two additions to the microscope consist of the substage with slit, &c., and the prisms in their box. The substage is of the ordinary construction, with screw adjustment for centering, and rackwork for bringing it nearer to or withdrawing it from the stage. In the accompanying engraving, A B is a plate of brass sliding in grooves attached to the lower part of the substage; it carries an adjustable slit C, a circular aperture D, 0·6 inch diameter, and an aperture O, ⅛ inch square. A spring top enables either the slit or one of the apertures to be brought into the centre of the field, without moving the eye from the eye-piece. Screw adjustments enable the slit to be widened or narrowed at will, and also varied in length. At the upper part of the substage is a screw of the standard size, into which an object-glass, shown at E, of high power, is fitted. The slit C and this object-glass E are about 2 inches apart, and if light is reflected by means of the mirror along the axis of the instrument, it is evident that the object-glass E will form a small image of the slit C, about 0·3 inch in front of it. A milled head F moves the whole substage up or down

* 'Proceedings of the Royal Society,' May 27, 1869.

the axis of the microscope, whilst screws G and H, at right angles to each other, bring the image of the slit into any desired part of the field. If the brass slide A B is pushed in so as to bring the circular aperture D in the centre, the substage arrangement then becomes similar to the old form of achromatic condenser. Beneath the slit C is an arrangement for holding an object, in case its surface is too irregular, or substance too dense, to enable its spectrum to be properly viewed in the ordinary way.

Suppose an object is on the upper stage of the microscope, and viewed by light transmitted from the mirror through the large aperture D and the condenser E; by pushing in the lower brass slide A B so as to bring the slit C in the field, and then focusing by the milled head F, it is evident that a luminous image of the slit C can be projected on to the object; and by proper adjustment of the focus, the object and the slit can be seen together equally sharp. Also, since the whole of the light which illuminated the object has been cut off, except that portion which passes through the slit, all that is now visible in the instrument is a narrow luminous line, in which is to be seen just so much of the object as falls within the space this line covers. By altering the slit adjustments the length or width of the luminous line can be varied, whilst by means of the rackwork attached to the upper stage any part of the object may be superposed on the luminous line. The stage is supplied with a concentric movement, which permits the object to be rotated whilst in the field of view, and thus allow the image of the slit to fall on it in any direction. During this examination a touch with the finger will at any time bring the square aperture O, or the circular aperture D, into the field instead of the slit, so as to enable the observer to see the whole of the object; and in the same manner the slit can as easily be again brought back into the field.

The other essential part of this spectrum microscope consists of the prisms. They are of the direct vision kind, consisting of three flint and two crown, and are altogether 1·6 inch long. The box K, holding them, screws into the end of the microscope body at the place usually occupied by the object-glass, and the object-glass L is attached by a screw in front of the prism-box. The prism-box is sufficiently wide to enable the prisms being pushed to the side when not wanted, so as to enable the light, after passing through the object-glass, to pass freely up the body of the instrument. A pin M enables the prisms to be thrown either in or out of action by a movement of the finger. As the prisms are close above the object-glass, the sliding-box N, carrying the Wenham binocular prism and the Nicol's prism, may be employed as usual, and the spectrum of any substance may thus be examined by both eyes simultaneously, either by ordinary light or when it is under the influence of polarized light. The insertion of the prism-box between the object-glass and

the body of the microscope does not interfere with the working of the instrument in the ordinary manner. The length of the tube is increased 1 or 2 inches, and a little additional rackwork may in some instruments be necessary when using object-glasses of low power. The stereoscopic effect when the Wenham prism is put into action, does not appear to be interfered with.

For ordinary work both these additions may be kept attached to the microscope, the prisms being pushed to the side of the prism-box, and the large aperture D being brought into the centre of the substage. When it is desired to examine the spectrum of any portion of an object in the field of view, all that is necessary is to push the slit into adjustment with one hand, and the prisms with the other. The spectrum of any object which is superposed on the image of the slit is then seen.

When the spectrum of any substance is in the field and a double-image prism is introduced, two spectra are seen, one above the other, oppositely polarized, the same lines being continued through the two; and the variations in the absorption-lines such as are shown by didymium, jargonium, &c., are at once seen.

If the substance under examination is dark coloured, or the illumination is not brilliant, it is best not to divide the light by means of the Wenham prism at N, but to let the whole of it pass up the tube to one eye. If, however, the light is good, a very great advantage is gained by throwing the Wenham prism into adjustment, and using both eyes. The appearance of the spectrum, and the power of grasping faint lines, are incomparably superior when both eyes are used; whilst the stereoscopic effect it confers on some absorption and interference spectra (especially those of opals) seems to throw entirely new light on the phenomena. No one who has worked with a stereoscopic spectrum apparatus would willingly return to the old monocular spectroscope.

If the illumination in this instrument is taken from a white cloud or the sky, Fraunhofer's lines are beautifully visible, and when using direct sunlight they are seen with a perfection which leaves little to be desired. The dispersion, being four or five times greater, is sufficient to cause the spectrum to fill the whole field of the microscope, instead of, as in the ordinary instrument, forming a small portion of it; whilst owing to the very perfect achromatism of the optical part of the microscope all the lines from B to G are practically in the same focus.

As the only portion of the object examined is that part on which the image of the slit falls, and as this is very minute (varying from 0·01 to 0·001 inch, according to the actual width of the slit), it is evident that the spectrum of the smallest objects can be examined. If some blood is in the field it is easy to reduce the size of the image of the slit to dimensions covered by one

blood-disc, and then, by pushing in the prisms, to obtain its spectrum.

If the object under examination will not transmit a fair image of the slit (if it be a rough crystal of jargon, for instance), it must be fixed in the universal holder beneath the slit, and the light concentrated on to it before it reaches the slit. If the reflected spectra of opaque objects are required, they can also be obtained in the same way, the light being concentrated on them either by a parabolic reflector or by other appropriate means.

By replacing the illuminating lamp by a spirit-lamp burning with a soda-flame, and pushing in the spectrum apparatus, the yellow sodium-line is seen beautifully sharp; and by narrowing the slit sufficiently it may even be doubled. Upon introducing lithium or thallium compounds into the flame, the characteristic crimson or green line is obtained; in fact, so readily does this form of instrument adapt itself to the examination of flame-spectra, that for general work I have almost ceased to use a spectroscope of the ordinary form.

The additional facilities afforded by the use of this instrument have led the writer to the discovery of one or two facts connected with the action of different bodies on the rays of the spectrum; and it has been considered that these may be of sufficient interest to the readers of the 'Quarterly Journal of Science' to be described somewhat in detail and illustrated by a few chromolithographs.

The mineral known as *opal* has long been prized as a gem, on account of the extraordinary beauty of its colours, but the phenomena underlying these flashes of colour have not been submitted to strict scientific examination. When a good fiery opal is examined in day-, sun-, or artificial light, it appears to emit vivid flashes of crimson, green, or blue light, according to the angle at which the incident light falls, and the relative position of the opal and the observer; for the direction of the path of the emitted beam bears no uniform proportion to the angle of the incident light. Examined more closely, the flashes of light are seen to proceed from planes or surfaces of irregular dimensions inside the stone, at different depths from the surface and at all angles to each other. Occasionally a plane emitting light of one colour overlaps a plane emitting light of another colour, the two colours becoming alternately visible upon slight variations of the angle of the stone; and sometimes a plane will be observed which emits crimson light at one end, changing to orange, yellow, green, &c., until the other end of the plane shines with a blue light, the whole forming a wonderfully beautiful solar spectrum in miniature. I need scarcely say that the colours are not due to the presence of any pigment, but are interference colours caused by minute striæ, or fissures lying in different planes. By

turning the opal round and observing it from different directions, it is generally possible to get a position in which it shows no colour whatever. Viewed by transmitted light, opals appear more or less deficient in transparency, and have a slight greenish, yellow, or reddish tinge.

In order to better adapt them to the purposes of the jeweller, opals are almost always polished with rounded surfaces, back and front, but the flashes of coloured light are better seen and examined when the top and bottom of the gems are ground and polished flat and parallel.

A good opal is not injured by moderate heating in water, soaking in turpentine, or heating strongly in Canada balsam and mounting as a microscopic slide.

If an opal which emits a fine broad crimson light is held in front of the slit of a spectroscope or spectrum microscope, at the proper angle, the light is generally seen to be purely homogeneous, and all the spectrum that is visible is a brilliant luminous line or band, varying somewhat in width and more or less irregular in outline, but very sharp, and shining brightly on a perfectly black ground. If, now, the source of light is moved so as to shine into the spectrum apparatus *through* the opal, the above appearance is reversed, and we have a luminous spectrum with a jet-black band in the red, identical in position, form of outline, and sharpness, with the luminous band previously observed. If instead of moving the first source of light (the one which gave the reflected luminous line in the red) another source of light be used for obtaining the spectrum, the two appearances of a coloured line on a black ground and black line on coloured ground may be obtained simultaneously, and they will be seen to fit accurately.

Those parts of the opal which emit red light are, therefore, seen to be opaque to light of the same refrangibility which they emit; and upon examining in the same manner other opals which shine with green, yellow, or blue light, the same appearances are observed, showing that this rule holds good in these cases also. It is doubtless a general law, following of necessity the mode of production of the flashes of colour.

Having once satisfied myself that the above law held good in all the instances which came under my notice, I confined myself chiefly to the examination of the transmitted spectra, although the following descriptions will apply equally well, *mutatis mutandis*, to the reflected spectra.

The following is a brief description of some of the most curious transmission spectra shown by these opals. The chromo-lithographs forming the frontispiece, taken from drawings with the camera lucida, convey as good an idea as possible of the different appearances. The exact description will, of course, only hold good

for one portion of the opal, but the general character of each individual stone is well marked.

The simplest form of band which is met with is shown in Spectrum 1, which represents the spectrum after passing through one of my experimental opals. It is one of the best examples I have met with of a narrow, straight, and sharply cut line. It is in the green, and might easily be mistaken for an absorption-band caused by an unknown chemical element.

Spectrum 2 shows a band of a very remarkable character; it is broad and black, and cuts diagonally across the green, touching the blue at the top and the yellow at the bottom.

Spectrum 3 is somewhat similar; it shows a broad indistinct diagonal band in the blue, and another still more indistinct in the violet.

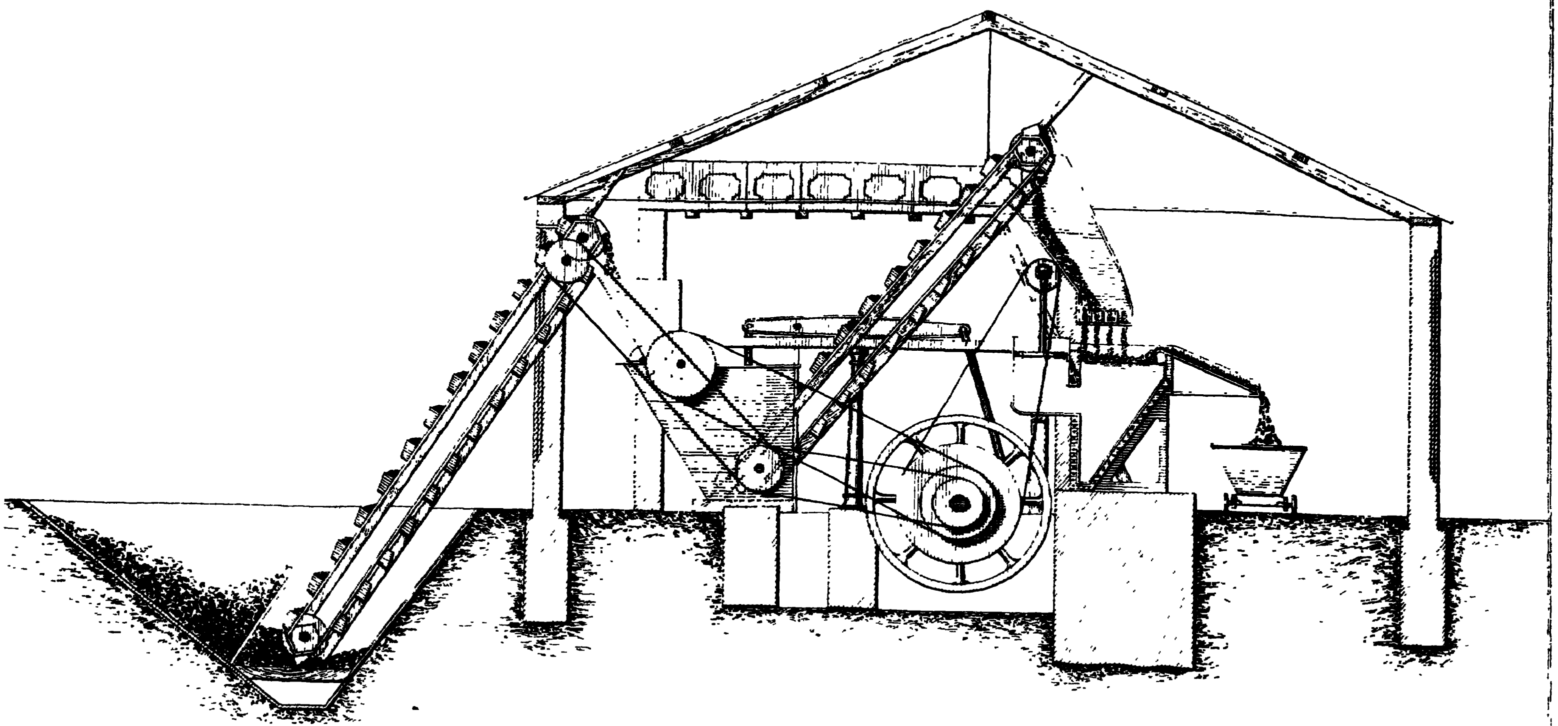
So far the bands have been simple lines, and the only peculiarity has been the diagonal character of some of them. I now wish to draw attention to a most remarkable phenomenon presented by some opals, and that is the production in their transmission spectra of irregularly shaded lines, which when examined in the binocular spectrum instrument appear distinctly spiral, and, on moving the opal, roll over on their axis from one part of the spectrum to another. Spectrum 4 is an example of this kind; it shows an irregular line in the orange. Viewed binocularly this exhibits a spiral structure in a marked manner, the different depths and distances standing well out: upon turning the milled edge of the stage adjustment, so as to carry the opal slowly from left to right, the spiral line is seen to revolve and roll over, altering its shape and position in the spectrum. It is not easy to retain the conviction that one is looking merely at a band of deficient light in the spectrum, and not at a solid body possessing dimensions and in actual motion.

Spectrum 5 shows the most striking example of a spiral rotating line which I have yet met with. On moving the opal sideways the line is seen to start from the red and roll over, like an irregularly shaped and somewhat hazy corkscrew, into the middle of the yellow. The drawing shows the appearance of this band in two positions.

It is scarcely necessary to say that the colour of the moving luminous line varies with the part of the spectrum to which it belongs. The appearance of a luminous line, slowly moving across the black field of the instrument, and assuming in turn all the colours of the spectrum, is very beautiful.

All these black bands can be reversed, and changed into luminous bands, by illuminating the opals with reflected light. They are, however, more difficult to see, for the coloured light is only emitted at a particular angle, whilst the special opacity to the ray of the same refrangibility as the emitted ray holds good for different angles.

LONGITUDINAL SECTION OF COAL WASHING MACHINE, WITH ENGINE &c



The explanation of the phenomena is probably as follows:—In the case of the moving line, the light-emitting plane in the opal is somewhat broad, and has the property of giving out at one end, along its whole height and for a width equal to the breadth of the band, say, red light; this merges gradually into a space emitting orange, and so on throughout the entire length of the spectrum, or through that portion of it which is traversed by the moving line in the instrument; the successive pencils (or rather ribbons) of emitted light passing through all degrees of refrangibility. It is evident that if this opal is slowly passed across the slit of the spectrum microscope, the slit will be successively illuminated with light of gradually increasing refrangibility, and the appearance of a moving luminous line will be produced; and if transmitted light is used for illumination the reversal of the phenomena will cause the production of a black line moving along a coloured field. A diagonal line will be produced if an opal of this character is examined in a sloping position.

The phenomenon of a spiral line in relief, rolling along as the opal is moved, is doubtless caused by modifying planes at different depths and connected by cross planes; I can form a mental picture of a structure which would produce this effect, but scarcely clear enough to enable me to describe it in words.

It is probable that similar phenomena may be seen in many, if not all, bodies which reflect coloured light after the manner of opals. A magnificent specimen of lumacelli, or fiery limestone, from Italy, kindly presented to me by my friend David Forbes, shows two sharp, narrow, and parallel bands in the red. I have also observed similar appearances in mother-of-pearl. The effects can be imitated to a certain extent by examining "Newton's rings," formed between two plates of glass, in the spectrum microscope.

II. COAL WASHING.

By F. C. Danvers, A.I.C.E., M.S.E.

In most mining operations it has been the practice, from the earliest times of which we have record, to wash the minerals obtained from beneath the surface of the earth in water, before subjecting them to further purification by means of fire, for the purpose of separating a portion of the earthy matters, with which they are invariably mixed, from the ore. In former years this was accomplished in a very rude manner, which doubtless involved the loss of a not inconsiderable amount of pure ore. Dr. Percy, in his valuable work on Metallurgy, gives an historical notice of the

mode of making iron in South Wales about the year 1750, in which it is stated as follows:—"On the wash, or enclosed ground on the sides of the hills, where we find ear, we dig a trench about 4 or 5 foot wide, till we come down to the lowest vein, about 14 foot deep, and in that depth is usually four veins or layers of oar. Then we make small ponds to hold rain water, or any that comes out of springs, above the trench that is cut; and as fast as the ponds fill, we let them down by a flood-gate into the trench, which carries away all the loose earth, and leaves the myne behind, and the lowest vein bare. They then undermine the banks of the trench on both sides, and when great quantities of the banks are fallen down, they let down the water out of the ponds again, which washes away all the earth from the myne." Such then was the rude method of washing iron ore 120 years ago; but although so primitive in method, the principle, it will be recognized, was the same as that which prevails in ore-washing machines of the most approved type at the present day, the separation of the ore from the earthy matters being due to gravitation. Thus whilst the lighter particles were carried away by the water, the heavier and mineral portions were left behind.

Although coal washing has now been practised all over the Continent for about half-a-century, until comparatively quite recently the practice of washing the products of coal mines was unknown in this country, and for the following reasons. Coal, unlike almost every other mineral product, is found running in broad seams, varying from a few inches to many feet in thickness; and so great is the quantity in which it exists that the richer seams only are considered worth working at all, and from these blocks are obtained, possessing a very high degree of purity. Not many years back, it was the custom to leave all the small coal down at the bottom of the pit, or, if it was brought to the surface, it was either burned at the pit's mouth as so much worthless refuse, or run to spoil. Indeed so wasteful has been the manner in which coal-mining operations have been carried on, that large quantities of valuable fuel have been lost, or habitually left at the bottom of the pit as not being worth raising to the surface. This subject was closely investigated in 1860, by Mr. Alexander Bassett, of Cardiff,* the result of whose inquiries showed that from thirty to forty per cent. of the products of mines is not unfrequently lost, owing to the imperfect method of coal "getting" usually adopted; but that where, either from the character of the seam of coal, or from the mode adopted in working, a less percentage of fuel is lost, "still, under the most improved system, the quantity of small coal left in the mines, and conse-

* "On the Large Proportion of Coal lost in Working." Paper read before the South Wales Institute of Engineers, in February, 1861, by Mr. Alexander Bassett, M.I.C.E.

quently for ever lost, bears a very large proportion to that raised, and which could be brought to bank, if a market were obtained for it."

Since attention was so forcibly called to the probable duration of our coal supplies by Sir William Armstrong at the Meeting of the British Association at Newcastle in the year 1863, measures have been devised with the view of utilizing that which was formerly counted as waste, and the sm ll coal is no longer permitted to lie unheeded at the bottom of the pit. In collecting the slack, however, in addition to any impurities which it contains as coal, such as shale, iron pyrites, &c., there will invariably be found mixed with it portions of rocky or earthy matters which have fallen from the roof of the heading during working, or which may be taken off from the floors of the passages whilst collecting the small coal for the purpose of sending it to the surface. Under these circumstances, it is not to be wondered that the slack coal thus obtained contains a much greater amount of earthy impurities than does the coal from the same pit, hewn and sent to bank in larger or smaller blocks. As has been already stated, this slack coal from the pits was formerly considered to be worthless, or, at any rate, not of sufficient value to enable it to bear the cost of transport in order to bring it to market; recent experience has, however, shown, not only that such is not the case, but that what was formerly looked upon as so much refuse, may be readily separated from the impurities with which it is in a great measure mixed, and thus purified it obtains a ready sale either for cokeing purposes or for the manufacture of artificial fuel.

The general large yield of English coal beds may, no doubt, be assigned as the chief cause which formerly led to the adoption of an extravagant mode of working them, and this was further stimulated by an absence of machinery for the purpose, and a want of that knowledge on the subject which has in comparatively recent times been acquired and put into practice.

The inferior quality of a portion of the coal measures of France and Belgium, and, in the former country especially, the comparatively small area over which they extend, led to the adoption of greater economy in working; and it is not therefore surprising to find that England is indebted to France for the introduction of the practice of coal washing, whereby the small and formerly unproductive yields of coal are now raised into an important branch of trade. Only a small portion of it is however brought into use in the manufacture of artificial fuel. That article is at present scarcely used in England, and the small quantity that is manufactured here is made almost exclusively for export. From the latest returns published, namely those for 1867, it appears that the amount of artificial fuel exported during that year from the United Kingdom was only 150,051 tons, which may be taken to

represent nearly the whole manufacture of it in this country. By recent improvements it is now possible to burn small coal in boiler furnaces, but by far the greatest portion of washed coal is converted into coke, for which purpose it is specially adapted, and at most large collieries in the country there may now be seen a coal-washing machine and ranges of cokeing ovens as part of the indispensable plant of the colliery proprietor.

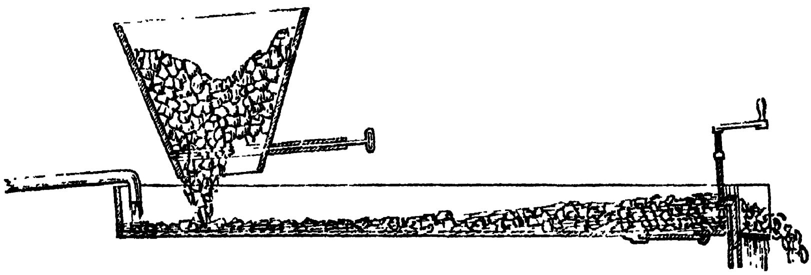
About sixteen years ago a Mr. Morrison first introduced into this country a coal-washing machine from France, and having obtained certain concessions from some of the north-country coal-owners, he proceeded to set the apparatus to work, and soon became celebrated for the superior quality of the coke manufactured by him. It was, however, some years before the principle of coal washing became at all general, and for some time Mr. Morrison was the only person to carry it into practice. Gradually, however, the process was taken up, first by one, and then by another, until a washing machine has now become almost as necessary an adjunct to a colliery as a pumping engine.

Very little alteration appears to have been hitherto made in the general principles of the first coal-washing machine introduced into this country, but alterations in detail have materially conduced to its greater efficiency and economy in working. As in the case of most other useful inventions, all sorts of modifications have been from time to time suggested, but few appear to have sufficiently recommended themselves on their own merits as to obtain any success. In all cases, excepting where only slack is washed, the coal has first to be broken up small, in order to prepare it for the washing machine. The means generally employed for separating the impurities from coal is gravitation, the mineral to be washed being thrown into water, when the earthy matters sink to the bottom, whilst the coal, being the lighter, forms an upper layer which is easily removed.

Numberless contrivances have been proposed for more readily effecting this disposition of strata in the washing machine, but, with the exception of those which we shall presently notice, few have come into general adoption; and whilst many other plans have been projected for removing the impurities from coals, those in which water is employed, either in a running stream or in agitation, as will be presently described, alone appear to have been brought into practical use. In order to give a better understanding of how the last-named machines effect this separation, we shall first describe them more in detail, and then proceed to give some further particulars regarding the methods requisite to prevent any unnecessary waste of fuel; since, if care be not taken, much coal is liable to be carried away with the waste water, after it has passed through the machines.

The simplest, but by no means the most efficient, form of coal-washing machine is that consisting of a simple trough, or passage, having a smooth channel, and set on a slight incline in the direction of its length, as shown in the accompanying woodcut. At the

FIG. 1.



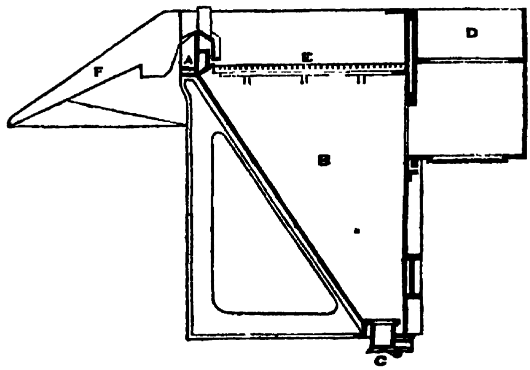
lower end, the trough is fitted with a vertical sliding sluice valve, working up through the bottom, and in grooves in the sides, which may be elevated or depressed at pleasure by means of a screw; and just above this sluice is placed a valve, opening in the bottom or side of the trough. The mode of working is as follows. The coal to be washed is either first crushed by passing it between rollers, or, as is sometimes the case, the trough is placed under the screen, over which the coals are tipped in passing from the trucks, as they come from the pit, into the railway waggons. The finer particles of coal then, passing through the meshes of the screen, fall into the trough at its upper or more elevated extremity, into which also a continuous flow of water is admitted. The coal is thus carried down the channel by the water, and it has to be kept constantly agitated during its passage, either by means of a long pronged fork worked by hand, or by a mechanical apparatus designed for the purpose. This agitation is necessary to ensure the more perfect separation of the coal from its impurities. As it flows down, the coal, being lighter than the shale or pyrites, rises to the top, whilst the heavier particles settle down and remain in the bottom of the trough. The coal then is permitted to pass over the sluice at the lower end of the shoot; but as the impurities accumulate, the sluice is gradually raised to prevent their passing away with the coal, and this is done until the sluice has been raised to a height nearly level with the top of the sides of the trough. The supply of coal is then temporarily turned off, and the valve opened in the bottom of the trough, through which the impurities are allowed to pass. The sluice is then lowered, and the same operation is repeated. In some machines of this type the trough is made very long, and a sluice is placed in the middle of its length as well as at the extremity.

Attempts have also been made to dispense with the necessity for stirring the coal whilst being washed, by placing a series of projections across the bottom of the trough, which, acting as submerged weirs, were intended to give the water an undulatory motion; this, however, is not sufficient for the purpose, and experience has shown that a more sudden and violent action of the water is necessary in order to effectually separate the coal from its impurities. The objections to this form of coal-washing machine are that, whilst it requires a larger supply of water for the purpose, the coal is not so thoroughly washed as in other machines; and that whilst the result is still only comparatively purified, a large amount of coal is probably wasted, by passing away with the other matters down the outlet valve before referred to.

The most generally adopted plan of coal-washing machine at present in use is that shown in the Plate accompanying this article. It is a modification of a French machine, the invention of one M. Bèrard, and somewhat of the form of that first introduced into this country by Mr. Morrison. The illustration represents not only the washing machine itself, but the steam engine and other auxiliaries employed in connection with it. In this machine the coal, after passing between crushing rollers, is conveyed by means of a "Jacob's ladder" into a hopper, or shoot, down which it falls into small rectangular troughs, at the head of each of which a current of water enters which carries the coal away, and deposits it on a wire, or perforated copper sieve. Beneath this sieve is a hopper-formed chamber filled with water in communication with the bottom of a cylinder in which a piston works at the rate of about 100 strokes per minute. The motion of this piston agitates the water in the "bash," causing it alternately to rise and fall on the sieve. The coal on the sieve is thus kept in a constant state of motion, being lifted up by the water as the piston descends, and falling again with its upward stroke. By this constant elevation and resettling, the heavier particles, which constitute the impurities in the coal, fall to the bottom and form the lowest stratum on the sieve; whilst the pure coal, after the space above the sieve is once full, is carried over the lip of the machine with the escaping water, and falls down a shoot into a truck placed there for the purpose of receiving it. As soon as any shale, or other impurity, is seen to pass over with the coal, or when the space over the sieve becomes filled with foreign matter (which may be readily ascertained by the attendant taking a small quantity out to examine it), the valve at A, Fig. 2, is raised by means of a screw, or weighted lever, and the accumulated impurities are allowed to pass into the lower part B, from which they are subsequently removed by means of the valve C at the bottom of the machine. The piston works in the chamber D. It should have a stroke of not more than from 2 to 2½ inches, and

is usually driven at the rate of about one hundred strokes per minute. E is the sieve on which the coal rests, and after being washed it passes away over the shoot F. A machine of this character, with pistons of 3 feet diameter, and "bashes" about 3 feet by 4 feet, will require a supply of about 32 gallons of water per minute for each "bash," and is capable of washing about 50 tons of coal per day per "bash." A four "bash" machine, capable of purifying nearly 200 tons of coal a-day, requires about a 12-horse-power steam engine to work it and the auxiliary machinery.

FIG. 2.



Having thus briefly explained the details of the washing machine itself, we pass on to notice the entire process through which the coal has to pass. The coal is brought direct from the pits in trucks, and emptied into the hopper sunk below the level of the ground, as shown in the left-hand corner of the engraving. Thence, if the situation does not admit of putting a pair of crushing rollers into the first reception pit, it is carried by a Jacob's ladder, and thrown into a hopper, through which it passes to the crushing mill, to be broken up into a suitable size for washing, by which process also the attachment between the coal and its impurities is severed or loosened. After passing through the rollers it is lifted up into another hopper, whence it falls into a number of short shoots corresponding with the number of "bashes" in the machine, and, a little above the point in the shoots where the coal enters, water is admitted through a service pipe, by means of which the coal is carried down on to the sieve, and the washing proceeds in the manner already explained.

According to one modification of this machine, which is in extensive use at Saarbruck, in Germany, a number of "bashes," instead of working separately, act together; the washed coal from one "bash" falling over a small weir into the next, and so on until it has passed through the entire series. Although, no doubt, by this mode a much greater degree of purity is obtained in the washed coal, the plan of using the "bashes" separately, as practised in this country, is found to give results sufficiently satisfactory for all practical purposes; to continue the process further would, therefore, only be to incur additional expenditure without corresponding results.

Another modification of the above process ought not to be passed by without notice, for, whilst it embodies most of the leading principles of Bèrard's machine, it has been so adapted as to produce the greatest possible effect with the least practicable amount of water and the smallest expenditure of power. The modifications in this machine—which has been designed by a Mr. Edwards—will be sufficiently well understood without an illustration, from the following description:—The coal and water are admitted together through a hopper on to the sieve, and instead of a piston, for keeping the water in the machine in a state of agitation, a float is placed so as to rest upon the surface of the water at a level below that of its height over the sieve. This float is attached to the top of the cistern, and the joint made water-tight by a leather flange, which admits of a certain amount of vertical movement by the float. The motion is given to the float by means of a three-throw cam; as the cam strikes the float, it is deflected, causing the water on the sieve to rise, in the same way as with the downward stroke of the piston in the machines already described. Indeed the float is in this case a piston working on the water only without any cylinder to work in.

Directly the cam releases the float, the head of water forces it back, ready to receive the next stroke. Instead of making the water act as the means of conveying the washed coal from the machine, as in Bèrard's and most other modifications of that machine, a set of scrapers gradually carry it forward, and finally push it over the delivery end of the machine, and thus less water is required. The speed at which the motion shaft is driven need be but one-third that of Bèrard's, in order to obtain the same amount of work. One of Edwards's machines, capable of washing about 50 tons of coal per day, requires so little power to move it, that, were it not for the auxiliary crushing rollers, &c., which are generally indispensable with a coal-washing machine, it might be worked by manual power.

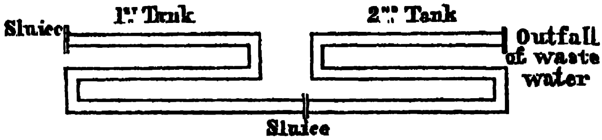
Most coal-washing machines are arranged so that the washed coal falls directly into a truck ready for removal to the cokeing ovens, to the artificial fuel manufactory, or any other destination. The coal thus caught forms, however, only a portion of what passes through the washing machine. It constitutes indeed the greater portion of it, and consists of all the larger pieces of coal, whilst many of the smaller particles and almost all the coal dust are carried away by the water as it flows off. In order to save this fine coal, which, it is found, contains the smallest amount of impurities, and is therefore best adapted for the manufacture of coke, it is necessary to form settling tanks through which all the water from the machine is made to pass. So much coal, however, escapes if due care be not taken, that it has in practice been found desirable

to have at least three such tanks, each of which should be in duplicate, so that one set of tanks may be kept at work whilst the coal which has collected in the other set is being removed. Sometimes a fine mesh wire gauze, or finely perforated plate, is placed at the outlet of the first settling tank for the purpose of keeping back all pieces of coal above a certain size, but it is very doubtful whether such a precaution is necessary, as the larger pieces are sure to be deposited in the first tank, wh st the finest of all will be found at the bottom of the last settling tank. Even after all these precautions have been taken to save as much of the coal as possible, the author has witnessed instances where samples, collected promiscuously from the residue which escapes with the water after it has passed through the last settling tank, have been found to contain seventy-five per cent. of combustible matter, but it is certain that a small portion only of this consisted of pure carbon. Under a judicious arrangement of settling tanks it will be almost invariably found that the deposited coal becomes more pure in each successive tank up to the third, and that what is subsequently found to be held in suspension by the water contains too large a proportion of impurities to render it worth the trouble and expense of collecting.

Too much attention can hardly be given to the construction of settling tanks, whatever form of washing machine is employed, since, in the first place, the fine coal passing away with the water is the purest and best adapted for the manufacture of coke, and secondly, unless this be carefully conserved the loss consequent upon the operation of washing may be such as to make it very questionable whether the cost is not out of all proportion to the benefits otherwise obtained. Even in a well-arranged coal-washing establishment the loss in weight by washing will often be found equal to from twelve to fifteen per cent., consisting of the impurities extracted, as well as a certain amount of small coal, which, as has been before explained, will always escape with the waste water. So far as the author's experience goes, there appears generally to exist at collieries a strong objection to devote a sufficient extent of ground to the proper construction of settling tanks. In setting them out care should be taken that the tanks are made only of such a width that they can be readily cleared out without the use of wheel-barrows; for this purpose they should not be more than 6 feet wide, and about 3 feet deep at the outside, and on either side of each tank trams should be laid, at a level somewhat below the surface, so that men may shovel the deposited coal directly into waggons. The tanks also should not consist of one long narrow trench each, as is most generally the case. For a large coal-washing establishment such an arrangement would be very inconvenient, and besides, it would not be found to work so well nor to deposit so much coal as if each tank were made to consist of three

or more rows of narrow trenches, communicating with each other at alternate ends, somewhat in the following manner.

FIG. 3.



Here it will be seen advantage is taken of the known tendency of any obstruction in the flow of water to cause it to deposit whatever matter it may hold in suspension. The total area of tanks required for any coal-washing works must depend upon the extent to which it is proposed to carry on such work, as well as in some measure upon the available amount of water for the purpose; it would, therefore, not be possible to lay down any general rules upon that subject, which must be determined after a consideration of the special circumstances of each case.

The cost of washing coal varies very much at different collieries, but it may be assumed that, on an average, it should not exceed threepence or fourpence per ton. At some places the washing is done by contract, one man receiving a certain sum for each ton of coal washed, and providing all the labour necessary, and paying all expenses connected with the operation. At other establishments, the engine employed to drive the washing machine may, perhaps, also be connected with other machinery, although it is better, in all cases, that it should have an independent engine for its own use. Under such circumstances, the cost of working the engine would be borne by the proprietors, and the person contracting would, of course, not be entitled to receive so high a price as if he were responsible also for the whole duty of the engine.

The practice of coal washing is, as we have already explained, a comparatively modern introduction in the economy of colliery management; but so rapid has been its extension within the last few years, that it is now coming into very general use. The advantages of thus purifying the slack of our coal mines are numerous, and calculated to benefit alike the producer and the consumer; for whilst it practically extends the available yield of our coal beds, it should have the effect of checking any inordinate increase of prices, if it do not actually tend to reduce the cost to the public at which certain classes of coal are now obtainable.

III. ON THE TEACHING OF NATURAL SCIENCE AT THE UNIVERSITIES.

THE indifference shown to the cultivation of the natural sciences in our leading public schools led to the appearance in the last number of this Journal of an article by our esteemed contributor, Dr. Lankester, which has caused no little discussion in circles where an interest is felt in such studies.

Whether or not the great chartered schools of Rugby, Harrow, Winchester, &c., are likely to be moved by the appeal of one who has spent a long life in promoting the study of natural science, and will appoint suitable professors and lecturers, we are unable to say;* but one result of the appearance of Dr. Lankester's article has been to show us that our Universities are by no means open to the charge of neglecting science, and are fully alive to the value of scientific studies.

We have received what we are bound to say are just protests against the neglect of science being laid to the score of the Universities, and consequently we hasten to rectify any erroneous impression which may have gone abroad as to the amount of time and money really expended at our Universities for the purposes of science tuition. And it affords us all the more pleasure to do this, inasmuch as we believe the public indifference to scientific knowledge has caused the efforts which have for some time past been made by the Universities to be overlooked, or to remain quite unknown, except to those who have been obliged by professional requirements to make science a portion of their education.

The fairest way, then, will be to let each University speak for itself; and as the first and loudest remonstrance reached us from Oxford, we shall print verbatim the programme of lectures, &c., with which it was accompanied.

The signature will remind our readers that the University possesses one of the most excellent museums in the three kingdoms, and that Drs. Rolleston and Phillips, Mr. Westwood, and others have long striven to make it as perfect as possible for educational purposes.

* Since this article was written we have been informed that a good deal is being done at Rugby and Harrow now. Good men are sent up for the Oxford scholarships from Rugby; and at Eton there has just been established a mastership in Natural Science, a gentleman having been engaged who was formerly Sir B. Brodie's demonstrator at Oxford.

SYNOPSIS

Synopsis of Lectures in the University Museum, Oxford, Lent Term, 1869.

Professorship.	Professor.	Subject.	Days and Hours.	1st Lecture.
Geometry	H. J. S. Smith, M.A.	An-harmonic Properties.	Monday, Friday, 1 P.M.	Friday, Jan. 22.
Astronomy	W. F. Donkin, M.A.			
Natural Philosophy	B. Price, M.A.	Dynamics of Material Systems.	Tuesday, Thursday, Saturday, 1 P.M.	Thursday, Jan. 21.
Experimental Philosophy	R. B. Clifton, M.A.	Acoustics (continued).	Monday, Thursday, 12.	Monday, Feb. 1.
Mineralogy	M. N. S. Maskelyne, M.A.			
Chemistry	Sir B. C. Brodie, Bart., M.A.	A Syllabus may be obtained at the Laboratory.	Tuesday, Saturday, 11 A.M. Catechetical Lecture, Thursday, 11 A.M.	Thursday, Jan. 28.
Anatomy and Physiology	G. Rolleston, D.M.	Circulation and Respiration.	Tuesday, Friday, Saturday, 1 P.M.	Friday, Jan. 22.
Geology	John Phillips, M.A.			
Medicine	Henry W. Acland, D.M.	General and Clinical Medicine.	Tuesday, Saturday, 11 A.M.	Tuesday, Feb. 2.
Botany and Rural Economy	Marmaduke Lawson, M.A.			
Zoology	J. O. Westwood, M.A.			

The University Laboratory is open daily from 10 A.M. to 4 P.M.

Classes are formed for practical instruction in Anatomy and Physiology. Gentlemen who join these Classes come to the Lecture on Saturday, and also attend on two other days in the week for study and demonstration.

Dr. Beale will give Demonstrations in Histology on Tuesday, January 26, at 8 P.M., and on following Tuesdays, at the same hour.

Mr. Chapman will continue his Course of Lectures on Physiology.

Mr. Wyndham will continue his Course of Lectures on Chemistry in Merton College.

J. PHILLIPS, *Keeper of the Museum.*

Passing on to the sister University, some of our readers have unfortunately been led by Dr. Lankester's article to think that the two lectureships named by him, as having been recently established, are the only chairs in natural science in the University; but this impression is not correct. At Cambridge there are professorships of physic, mathematics, chemistry, astronomy, and experimental philosophy, anatomy, botany, geology, a second of astronomy, geometry, medicine, natural and experimental philosophy, mineralogy, and archæology; and examinations in all those subjects, as well as in mechanical and applied science.

Of London University it is hardly necessary to speak. Its numerous scholarships and its degrees of Bachelor and Doctor of Science have done as much, perhaps more than any institution in the world, for the promotion of scientific education. Nor must the large public schools and colleges in London and the provinces which are connected with it be overlooked. Of these it is only necessary to mention University and King's Colleges, London; Owen's College, at Manchester; Queen's Colleges, at Birmingham and Liverpool, to remind our readers that great efforts are made to provide scientific instruction for those who seek it.

The Scotch Universities have not been idle. One of our correspondents, who complains that justice has not been done to Edin-

burgh University, sends us the following details, to which we gladly give publicity:—

"Systematic instruction in botany, chemistry, natural history (in which are included zoology, geology, mineralogy, physical geography, and meteorology), natural philosophy, including optics, heat, electricity, magnetism, hydrostatics, and mechanics, has for a very long period been imparted in the University of Edinburgh. The chair of botany was founded in 1676, that of chemistry in 1713, and that of natural history in 1767; the chair of natural history is also old-established. The instruction imparted from these chairs is not merely in the form of lectures; but laboratories, museums, and a botanic garden are provided for the practical instruction of the students. The students attending botany, chemistry, and natural history are, to a considerable extent, medical, but a very fair proportion of general students participate in the instruction. Attendance in the class of natural philosophy is imperative on all candidates for the degree in Arts conferred by the University, but many students who have no intention of proceeding to the Arts degree also attend. Candidates for honours in the faculty of Arts can, if they choose, present themselves for examination in geology, zoology, chemistry, and botany.

"The University also confers the degrees of Bachelor and Doctor of Science. Candidates are examined in botany, chemistry, zoology, geology, natural philosophy, and mathematics. Through the liberality of Sir D. Baxter, scholarships in the natural and physical sciences have been founded."

Speaking of other Scottish institutions, our correspondent goes on to say that in Glasgow and Aberdeen there are corresponding chairs in the biological and physical sciences; and he also forwards us a programme of the course of science-teaching in the High School at Edinburgh, which embraces chemistry, natural philosophy, zoology, and botany.

Turning now to Ireland, from whence, too, an admonition has reached us, we believe we can safely say that whilst the Universities (Dublin and Queen's) do all they can to set a good example, nothing is done by the public schools.

At Dublin, moderatorships in experimental science were first given in 1851, the course consisting of physics, chemistry, and mineralogy. Subsequently geology was introduced, and in 1858 zoology and botany were added; and the name of the moderatorships changed to "Experimental and Natural Science."

There are professorships of mathematics, natural philosophy, chemistry, zoology, botany, civil engineering, geology, applied science, and mineralogy; to these, museums of natural philosophy, zoology, and archæology, anatomy, engineering models, and botany are made subservient.

At the Queen's University, science is largely cultivated, and there are professorships of natural philosophy, chemistry, natural history, geology and mineralogy, anatomy and physiology, and engineering; scholarships are awarded in science, and a special diploma for engineering.

Thus it will be seen that in all our large Universities ample provision is made for science-teaching, and it is greatly to be feared that the reason why this branch of human intelligence has not been hitherto more largely cultivated there, is not so much on account of the indisposition of the College authorities to afford instruction, as to the unwillingness of the students to receive it.

The late respected Dr. Daubeny wrote to the writer of this article some time before his death, expressing his regret that more encouragement is not given to the study of science by the middle classes. A demy-ship in natural science at Magdalen College, he said, was literally going a-begging, and the writer was asked whether he could recommend a candidate. One reason for this indifference—probably the chief one—was soon made apparent when the attempt was made to comply with the Doctor's wishes. "What am I to do for a living, after I have completed my studies?" asked one young man. And this question contained the solution of the mystery—science does not pay. The great prizes are to be found at the Bar, or in the career of a statesman, and unfortunately scientific knowledge is not yet appreciated in those professions.

But why the Universities of Oxford and Cambridge should withhold honour where there is no profit; should offer facilities for instruction and yet deny the student the reward of merit, is a mystery. The sooner they encourage the pursuit of science by conferring degrees for its proficiency, and thus making it at least an honourable profession, the better it will be both for the teacher and the taught. We trust the day is not far distant when the example of the Universities of London and Edinburgh will, in this respect, be followed by the older Universities, which should rather lead than follow in every intellectual movement of the day.

IV. THE MINERALOGICAL RESOURCES OF IRELAND.

As compared with either England or Scotland, the mineral resources of Ireland are limited in extent, and not very rich in kind. Of several species of rocks and formations, which are of economic value, there is indeed an abundance. Ireland can produce the noblest specimens of granite, serpentine and marble, and prodigious quantities of limestone, chalk, and other massive rocks; but when we

come to consider the extent and nature of her resources in coal or iron, we cannot but feel that she labours under disadvantages which go far to explain the causes of the comparative impoverishment and the almost purely agricultural habits of her population.

Without large supplies of coal and iron, especially the former, it is needless to say that no country can take a foremost rank in those arts and manufactures which are the sinews, not only of war, but of peace. And notwithstanding the deficiency in these commodities, from which Ireland suffers, it is highly to the credit of the inhabitants of Ulster that in one branch of manufacture—the linen trade—this province has no superior, scarcely a rival. This branch of manufacture, introduced by the Protestant refugees from France, is carried on by the aid of imported coal and native-grown flax, and has been the means of making the town of Belfast the second in importance only to Dublin, and amongst the most thriving, spirited, and industrious centres of industry in the British empire.

But notwithstanding several successful attempts in Belfast, Dublin, and elsewhere, to compete with the sister-country in engineering, ship-building, and iron manufacture, Ireland is, and must ever be, an agricultural and pastoral country. For this she is peculiarly adapted by the genial character of the climate and the richness of the soil; for any other she is disqualified. We look in vain for those vast deposits of coal, or those stores of iron ore, with which England and Scotland have been so richly endowed, and from which they derive such solid advantages. Nature has, we think, dealt hardly by the sister-isle; for we have very good evidence for believing, on geological grounds, that the coal-fields of Ireland must have been, at some distant period, proportionably greater, as regards the area of the country, than those of Britain. This assertion may startle some persons who are not versed in the process of inductive reasoning on geological principles; and, for their sake, we shall shortly state the grounds upon which we base this conclusion.

If we examine the coal-fields of England, we shall find that, with few exceptions, their lowest strata repose upon a basis of Carboniferous limestone. Whether we examine the coal-bearing tracts of South Wales, Gloucestershire, and Somersetshire on the south, or of North Wales, Lancashire, Cumberland, &c., on the north, we find layers of this limestone supporting strata of shale, sandstone, and grit, which become more carboniferous as we ascend in the series; and ultimately pass up into the series of strata which, on account of their most important feature, are denominated "Coal-measures." Now, throughout this series of strata we observe a gradual change from the calcareous beds at the base to the coal-bearing shales and sandstones of the upper part; the limestones near their junction with the Millstone grit and Yoredale beds

becoming gradually more earthy, and being split into separate layers by the intercalation of shales and sandstones. Throughout the whole series, amounting vertically to several thousands of feet of strata, there is no abrupt change, or break, in the succession of the beds of any importance; a fact which should be borne in mind, because on it depends much of the strength of our reasoning from analogy when we come to the case of Ireland.

Now, reverting to this country, what do we find? We find the very same succession of strata, from the base upwards, through a certain distance in the vertical scale, but no farther. We may observe the Carboniferous limestone—the basement layer of the coal-bearing superstructure in Britain—spread over an enormous tract of country, and forming nearly the whole of the central plain of Ireland; and resting on this, at intervals, we have small tracts of strata, with a few thin seams of coal, representing the Millstone grit and Yoredale series of England and Wales; but here the succession ends. We look in vain for the deposits of coal-bearing strata —or true Coal-measures—which in Britain are the repositories of the most important beds of mineral fuel.

To account for this want—this truncation, in fact, of the most economically important portion of the great Carboniferous formation in Ireland—the geologist has a theory which is intelligible and consistent with experience as obtained in some parts of Britain itself. Our readers are probably familiar with the tracts of hilly ground in parts of Yorkshire and Derbyshire, called "the Penine Chain," which separate like a "backbone" the coal-fields of Lancashire and Cheshire on the one hand from those of Derbyshire and Yorkshire on the other. These hills are composed of Carboniferous limestone and Millstone grit, the basement series of the Coal-measures; and no one familiar with the similarity of the strata on either side of this dividing ridge can doubt for a moment that the strata of which the ridge is formed were originally overspread by deposits of coal-bearing strata. Equally certain is it, that a large portion of the Carboniferous limestone of the central plain of Ireland was once overlaid by coal deposits; but they are gone, as are those of the Penine Chain in Derbyshire; and in both cases they have disappeared through the agency of "denudation," a term by which we express the removal of masses of strata, by the agency of rivers, seas, and other forms of water at distant periods of the earth's history.

Denudation, then, has despoiled Ireland of her mineral resources, and for all time has moulded the character of her inhabitants. Who can say, how different might have been her history had an abundance of mineral wealth stimulated the natural genius of her sons, and rendered her the centre of mining and manufacturing industries!

From these speculations let us now turn to the consideration of

those mineral resources which still are left. Commencing with the most important—namely, coal—we find that there are the following coal-fields, some of which are to be regarded, however, as almost worthless, as far as our information extends :—

1. County Clare (Connaught Coal-field). 2. Kerry and Limerick (Munster Coal-field). 3. Tipperary and Kilkenny (Leinster Coal-field). 4. Leitrim and Fermanagh. 5. Meath. 6. Dungannon, co. Tyrone. 7. Ballycastle, co. Antrim. Besides which, there are several small tracts of unproductive Coal-measures.

1. *Co. Clare.*—This coal-field is only partially explored. It extends from the north bank of the estuary of the Shannon to an apex a few miles south of Galway Bay, and from the Atlantic coast inland nearly as far as Ennis. It contains several seams of coal, the thickest being about 30 inches, as also bands and nodules of clay-ironstone. The following section by Messrs. Kinahan and Foot, of the Geological Survey of Ireland, gives a general view of the succession of the strata where they occur in greatest thickness: *—

General Section—County Clare.

		Ft.	In.
8.	Shales principally—thickness uncertain.		
7.	Money Point-flags	150	0
6.	Shales principally	200	0
	Coal	1	6
5.	Intermediate beds, about	600	0
	Coal	2	6
4.	Intermediate beds, about	700	0
	Coal	0	6
3.	Grits and shales, about	930	0
2.	Lower flagstone series, about	70	0
1.	Shale series, about	500	0
		3150	0

2. *Kerry and Limerick.*—This coal-field is a continuation to the south of the estuary of the Shannon of that which has just been described. In proportion to its enormous extent, it is far from productive. At Coal Hill and Knocknaboola collieries, situated near the banks of the Shannon, seams varying from 6 inches to 3 feet have been worked, but only to a small extent. The seams are either anthracite or culm, and appear to be of very limited range.† In other parts of the district, according to Professor Jukes, the coal-beds are often highly inclined, contorted and compressed, so as to be only a few inches in thickness for many yards, and then suddenly expand into large pockets of coal of a thickness of 20 or 30 feet; under these conditions the coal is sometimes extracted in the manner of working metallic lodes.

* 'Explanation of Geological Survey Map 142,' p. 9. 1860.

† For an account of these coals, and the mode of working, see 'Explanation of Geological Survey Map 142,' by Mr. Kinahan, p. 36.

Clay-ironstone was formerly extensively worked from the shales which overlie the uppermost coal-seam, both at the Rock Colliery and south-east of Glin. Here there was a furnace for smelting the ore, but the ironstones are generally too poor in quality and too small in quantity to make them of any economic value.

3. *Tipperary and Kilkenny.*—This is one of the most important coal-fields in Ireland, and has been ably described by Sir R. Griffith, in his 'Report on the Leinster Coal-field,' and more recently by the officers of the Geological Survey.* The coal is of three varieties, known in the district as *anthracite, culm,* and *kelve.* Of these the anthracite is the most valuable, and the kelve the least, being merely a carbonaceous ferruginous shale, with so much combustible matter as to be used for fuel. The culm is extensively used for brick-making and lime-burning; and the anthracite, which is generally highly pyritous, when ignited gives out an intense heat. The following is a general section of the strata of this coal-field in its thickest part:—

General Section near Castlecomer.

	Ft.	In.
Uppermost strata	12	0
Peacock coal	1	10
Intermediate strata	45	0
Stony coal	3	0
Intermediate strata	21	0
Double seam of coal (partly fireclay)	5	0
Intermediate strata	120	0
Three-foot seam of coal	3	0
Intermediate strata	180	0
Foot coal	1	6
Intermediate strata (about)	300	0
Gale Hill coal	0	6
Flagstone series (about)	650	0
Black shale series	500	0
Carboniferous limestone.		

The lowest seam of coal is not workable, but the "foot" and "three-foot" seams have a considerable range, and have been largely worked. The uppermost seams occupy only a very limited area, as they have been denuded from off the greater portion of the coal-field. Along with the seams of coal are several beds of clay-ironstone of fair quality and thickness. These were once mined and smelted at Moyhora and Lacka, in the Queen's County. In the deep workings at Massford, and at Coolham Hill, Moyhora, Moyadd, and other places, the old workings were on an extensive scale.† This coal-field possesses sixteen collieries now at work.

4. *Leitrim and Fermanagh.*—This coal-field is of considerable extent, lying to the north of, and around, the shores of Lough Allen. It contains several seams of coal, at least two of which are workable,

* 'Explanation of Geological Survey Map 137,' by Messrs. Jukes, Kinahan, and Du Noyer. 1859.

† Mr. G. H. Kinahan's 'Explanation of Geological Survey Map, sheet 137,' p. 51.

and one of bituminous coal of fair quality, which is worked near Cashel. There are several collieries in the vicinity of Boyle and Drumkeeran. As the Government surveyors have not as yet entered upon the examination of this district, we are as yet only partially acquainted with its mineral resources.

5. The little coal-tracts of the county Meath are also only partially explored, but it is well known that the beds of coal are of very limited extent.

6. *Dungannon.*—The area of this coal-field does not exceed twelve square miles, only part of which is productive of coal; but as compared with the coal-tracts we have been considering, it is comparatively rich in minerals, which have been examined and described in detail by Sir R. Griffith.

Unlike the coal-fields of the south and west of Ireland, which are on every side bounded by the Carboniferous limestone or the Atlantic Ocean, the Tyrone coal-field is bounded to the south and east by the New Red Sandstone formation, below which the seams of coal may be considered to dip, and to be within reach of mining operations. The coal-field is divisible into two districts, namely, that of Coal-Island and Annahone: the former, according to the estimate of Sir R. Griffith, has an area of about 7000 acres, and the latter over 300 acres. The general section in its deepest part is as follows:—

SECTION OF THE TYRONE COAL-FIELD.

	Ft.	In.
Upper coal (impure)	2	2
Intermediate strata	37	0
Annaher coal (soft)	9	0
Intermediate strata	55	0
Bone coal	3	0
Intermediate strata	39	0
Shining coal	2	10
Intermediate strata	78	0
Brackaveel coal (good quality)	4	6
Intermediate strata	74	0
Baltaboy coal (sulphurous)	3	0
Intermediate strata	72	0
Gortnaskea coal (partly cannel)	6	0
Intermediate strata	225	0
Derry coal (good quality)	4	6

Below these are several other seams, and as a general rule the coal of this district is of fair quality, and is associated with several beds of ironstone and fireclay.

To what extent this coal-field underlies the flat tract of ground which stretches eastward to the banks of Lough Neagh, and southwards to the banks of the river Blackwater, is a question of economic importance remaining to be solved. It is to be hoped that beds of coal, of such value both as regards thickness and quality as to resemble those of several of the English coal-fields,

will be ultimately found like them to extend far beneath the Triassic strata, and to become a source of industry and wealth to the country around.

7. *Ballycastle, Co. Antrim.*—This isolated coal-tract extends along the southern shore of Ballycastle Bay to Fair Head, and southward to Murloch Bay. It is of small extent, the strata reposing on a floor of crystalline schists, and being surmounted by a sheet of columnar basalt, which is visible along the fine cliff of Murloch Bay. There are (or rather were) several good seams of coal, which appear to have been worked from very early times, the old passages and chambers having been unexpectedly discovered by the miners in the year 1770. The coal is now, however, nearly exhausted, but there still remain at least two seams of "black-band" ironstone, which are now being worked, and exported to the smelting furnaces belonging to the firm of Messrs. Merry and Cunninghame, in Ayrshire.

The above concludes our review, necessarily brief, of the coal-fields of Ireland. It will be apparent that, in a national point of view, the extent of their resources is altogether unimportant. Perhaps the largest proportion of the valuable seams of coal have already been worked out, and with the exception of the district of Dungannon, it is clear that even the local demands of the country must be supplied from British sources of supply. In the absence of coal, peat is the kind of fuel upon which the population of the country mainly depends; fortunately the supply of this is almost unlimited, and is to some extent being constantly restored by new growths as the process of extraction proceeds.

In 1868 there were about thirty-four collieries, often of small size, in work, producing 126,950 tons of coal, as appears from the "Mineral Statistics" for that year.

That iron was formerly smelted from native ores to a considerable extent there is abundant evidence, both from documents and the remains of old workings in many parts of the country. During the last century much of the timber which once clothed the surface of the country, and of which the relics are to be found in every bog and morass, was felled for the supply of the iron-furnaces, some of which survived into the present century. The superior resources of the Welsh, English, and Scotch iron-fields effectually terminated smelting operations in the sister-isle; nor are they likely to be resumed.

The chief source of this metal was the clay-ironstone of the Coal-measures; but there was a large quantity obtained from bog-iron-ore and hæmatite. A new source has lately been opened up in the province of Ulster. A band of ochreous ore underlying the basalt of county Antrim is now worked along the northern shores of Belfast Lough, and is exported to Scotland.

As regards the remaining useful metals, it is only necessary to mention that ores of lead, zinc, copper, silver, and native gold occur in various parts of the country, especially in the counties of Wicklow, Waterford, Tipperary, Monaghan, Kerry, Galway, Dublin, Donegal, Cork, and Clare. We have only to cast our eyes over the catalogue of localities where mines, or metalliferous veins have been discovered, published by the General Valuation Office, under the superintendence of Sir Richard Griffith, to be assured that the country is rich in minerals, only partially developed. Beds of rock-salt have been recently discovered near Carrickfergus, and gypsum near Kingscourt, in county Meath. Nor in this brief summary of the mineral resources of Ireland may we omit to mention—the encrinital marbles of Galway, Cork, and Dublin; the granites of Wicklow, Down, and Galway; and the rich serpentinous marbles of Connemara.*

* For an account of the mines of the county Wicklow the reader is referred to the 'Records of the School of Mines,' vol. i., part iii., by Mr. Warrington W. Smyth, F.R.S. (1853); and for the districts of the south and west of Ireland, to the 'Explanations of the Geological Survey Maps,' published by the Geological Survey of Ireland.

CHRONICLES OF SCIENCE,

Including the Proceedings of Learned Societies at Home and Abroad; and Notices of Recent Scientific Literature.

1. AGRICULTURE.

A GOOD harvest month has somewhat improved the grain produce of the year, which, however, as regards the wheat crop, is considerably below the average, and very much inferior to our experience of last year. The great agricultural meeting at Manchester has given to our leading manufacturing population a better idea than they before possessed of the real status as well as of the relative position of the food manufacture among the other manufactures of the country. So admirable a collection of specimen products, and especially of our various breeds of live stock, was never before exhibited; and the immense collection of agricultural machinery, which Manchester spectators most of all were likely to appreciate, could not fail to give the impression that the agricultural body had contributed quite their share to that ideal of energy, promptitude, practical ability, and success to which we give the name—John Bull.

In the Parliamentary session just closed two important agricultural measures have been enacted, one of which assumes, properly enough, that English farmers cannot take care of themselves; of the other, differences of opinion on this point exist. The former lays certain restrictions on the trade in foreign live stock, providing for such a separation or quarantine of imported animals as shall hinder the introduction of infectious diseases; the latter inflicts penalties on any one who shall kill or dye seeds for fraudulent purposes. The practice had become notorious, and called for remedy: but it is believed by many that the true remedy is already in the hands of the farmer, and needs no legislative supplement. Better teach a great community, whose ability is so well illustrated by every agricultural meeting, the art of taking care of themselves, than surround them with enactments for their safety.

The analysis of manures, however, much more than the analysis of seeds, has long been known as an efficient protection against fraud in the artificial manure market; but it appears now that a guarantee by the chemist of so much per cent. of soluble phosphate cannot be depended on for any length of time. Soluble phosphates do under certain circumstances fall back into their original chemical condition by mere lapse of time. And a recent trial proves that twenty-four per cent. of soluble phosphate may in a few weeks become eighteen or nineteen per cent. without any

taint of dishonesty attaching to either salesman or warehouseman. Other phosphates besides those of lime are now used in the manufacture; and thus, use as much sulphuric acid in their conversion as you will, a portion of the phosphate which it makes soluble in water becomes in time insoluble in water—reprecipitated, as it were, in the substance of the superphosphate itself, or in other words, it is again reduced. After all, however, the effect of the original solution is not entirely lost; the process which thus prematurely takes place does in every case ensue upon the addition of a superphosphate to the soil; and it is the finely divided condition of the resultant neutral phosphate in the soil, not the easily soluble condition of superphosphate which is applied to the soil, on which the immediately fertilizing power of the manure depends.

The subject of thin seeding has occupied a good deal of attention lately in agricultural journals. The practice of sowing two or even three bushels of wheat per acre seems on the face of it a monstrous waste of seed. There are thus 1,200,000 to 1,800,000 grains sown on every acre, corresponding to from 30 to 40 seeds on every square foot of ground! which is apparently absurd. And no doubt it is really wrong in the great majority of cases; nevertheless the question is one not for the arithmetician, but for the agriculturist. The object is to get the greatest possible crop; and if, as the 'Agricultural Gazette' points out, the practice of sowing 20 or 30 seeds per foot proves right during the harvest month, we can well afford to neglect the arithmetical proof of its folly and absurdity which it will receive during all the other eleven months of the year. In practice the quantity of seed sown per acre has gradually diminished of late years, and 5 or 6 pecks of wheat are now commonly sown per acre, where 8 or 10 used to be the common allowance. Among matters of personal interest which have occupied attention during the past quarter, we may name the publication of a memoir of the late John Grey, of Dilston, by his daughter, Mrs. G. Butler. It is the biography of a large-hearted and accomplished man, whose great and good influence upon agricultural progress it will materially help to maintain. The labours of Mr. W. Smith, of Woolstone, as the pioneer of steam cultivation, have been the subject of discussion and recognition. The visit of M. Dumas, the distinguished French chemist, to this country, and notably to the experimental farm of Mr. Lawes at Rothamsted and to the sewage farm at Barking, deserves a record for the attention which was directed by it at once to the long-continued and most valuable labours of our great agricultural chemists, Messrs. Lawes and Gilbert, in the domain of agricultural theory, and to the leading question in the field of agricultural practice, which is receiving so satisfactory a solution in the hands of the Metropolis Sewage Company.

2. ARCHÆOLOGY (Pre-Historic),

And Notices of Recent Archæological Works.

It is now five years since Professor Owen read before the Royal Society the first part of his paper "On the Human Remains from the Cave of Bruniquel." Early in the present year he communicated the second part, containing the account of the Equine remains.

This cavern, situated in a limestone cliff on the north side of the valley of the Aveyron, Département Tarne et Garonne, was explored by its proprietor, the Vicomte de Lastic St. Jal, in 1863, and a suite of the remains (selected by Professor Owen) were secured by the Trustees for the British Museum.

Although this deposit is chiefly rich in remains of the Reindeer and Wild Horse—both these animals having been eaten in great numbers by the ancient denizens of the cavern—there is here a total absence of the remains of the Cave-lion, Cave-bear, Hyæna, and those large extinct pachyderms that have elsewhere been found in ossiferous deposits.

Of the existence of early man in Western Europe with the Mammoth, Rhinoceros, Hyæna, &c., there can now be little doubt; but at the time when he occupied the caves of Dordogne and the Aveyron, and left behind, in the hearth-stuff of these caves, such indubitable evidence of his long-continued residence, the larger pachyderms and more formidable beasts of prey had apparently given place to vast migratory herds of Reindeer and Wild Horses, upon which the Cave-men subsisted, and of the bones and horns of which their weapons of the chase were made.

The mammalian fauna of such caves as Kent's Hole, Torquay, or Genista Cave, Gibraltar, may be more varied and remarkable, but as regards the excellence of the drawings of animals on some of the bones, the fine workmanship of the barbed harpoons and bone needles, no cavern has yielded a better or finer series than that of Bruniquel.

We shall look forward with much interest to the publication of Prof. Owen's valuable paper in the 'Philosophical Transactions.'

In some notes "On the Sutherland Gold-field," by the Rev. J. M. Joass, communicated to the Geological Society by Sir Roderick I. Murchison, Bart.,* the author refers to the Pictish Towers, a class of ancient buildings very numerous in Sutherland, and specially abundant within the ascertained auriferous district. These towers, wherever they occur, from Shetland to the south of

* See 'Quart. Journ. Geol. Soc.,' vol. xxv., pp. 317–326.

Inverness-shire, appear to be associated with rocks which may be more or less auriferous—namely, the Lower Silurian.

These forts have no doubt been erected against maritime invaders. Their number and strength suggest the frequency and formidable nature of such inroads, for which a motive may be found in the supposition that south-eastern Sutherland and other districts where such duns or burgs occur, were known in pre-historic times to be rich in gold or other mineral treasures.

Hence, perhaps, the connection between the copper of Sandness and Mousa-burg, in Shetland; the lead and silver of Beaufort and Struidh-burg, in Inverness; the gold of Durness and Dun-Dornadilla, in west Sutherland; of Uisge-dubh and Caisteal-Coille; of Allt-Smeorail with Aschoille-burg on the one side, and Coir-Aoiscaig tower on the other; and of Strath Ullie, with its chain of Pictish strongholds from Dun-uaine on the coast to the wonderful group of Cyclopean structures that crown Beinn-Ghriam-beg, twenty-eight miles inland.

Hence too, perhaps, the origin of the native torques and armillæ of beaten gold, attractive booty no doubt to the roving Norsemen, "the extractors of rings"; and hence, also, it may be, one reason why the largest nugget lately found weighs only 2 oz. 17 dwts., if we suppose that the gold discoverable without washing or other modern appliances had been picked up by the pre-historic people.

Mr. George Anderson lately communicated to the Geological Society of Edinburgh an interesting description of Craig Phadrich, a vitrified fort near Inverness. This pre-historic fortress occupies the termination of a rocky ridge (about 250 feet in height) in the long chain of mountains which skirt the west of the great glen of Scotland, and fronts the Ordhill of Kessock, another vitrified fort on the opposite Ross-shire coast.

It forms the advanced beacon-station on the Moray Firth, from which signals could be passed by each successive link of the chain of natural telegraph-stations stretching far into the recesses of the country beyond the head of the Beauly Firth, in Ross-shire, Glenstrathfarar and Strathglass, as well as in the great glen.

Six or seven vitrified summits are visible from Craig Phadrich, and if the ordinary hill-forts, having huge ramparts of stone round their tops, belong to the same period, that number might be nearly doubled. Craig Phadrich stands on a hill of Old Red Sandstone, capped with a mass of hard conglomerate, with precipitous faces on the north and south sides, and steep ridges of approach on the east and west. These approaches were guarded by two walls or embankments—one, a very strong and high one on the summit, composed of loose stones, sand, and gravel—the other about 50 feet lower down the slope, less massive but much more highly vitrified. The pathway up the western side is extremely narrow and tortuous, and

flanked by projecting masses of rock, from which loose stones could be readily hurled on an invading foe. The eastern ascent is the main approach, but the entrance is so strongly fortified by projecting walls or bastions that it could readily have been defended from above.

In the upper rampart the vitrified stones occur intermixed with others not affected by fire, and with loose sand and gravel. In the lower, or outer wall on the south side, the fusion has been much more complete, pieces of granite, gneiss, mica-slate, and quartz-rock, with some bits of sandstone, being all fused together. Mr. Anderson observed long strings of vitrified matter which had poured down from the melted mass above among the loose materials beneath.

The writer has carefully examined similar vitrified forts in the Sidlaw Hills, overlooking the valley of the South Esk.

Bearing in mind the infusible materials of which these walls are built, it seems almost incredible that a rude and savage race should have resorted to the agency of fire to consolidate them. The heat required even to vitrify the exterior of a mass of granite must have been not only very intense, but such as would endure for many days. In Craig Phadrich the fusion of the walls had penetrated for 12 or 14 inches into the mass.

In the 'Natural History Transactions of Northumberland and Durham,'* the Rev. G. Rome Hall investigates the origin of certain Terraced Slopes in North Tynedale. These terraces occur in the borders of the valley of the North Tyne and the river Rede, near to the Roman Wall and Watling Street, and close to the sites of numerous British camps. They have been examined by the geologist, the military engineer, the practical agriculturist, and the archæologist, and each, from his own particular stand-point, has traced their formation to widely different agencies. The author describes and maps upwards of seven sets of these terraced slopes: four sets near the village of Birtley; two sets near Swinburne Castle, and another series near Wall Camp Hill, &c.

The terraces of Steel Burn are 400 yards long, about seven to ten in number, and face to the south-west; another set, ten in number, are 150 yards long, and face the west. The next series are seven to eight in number, each several yards in breadth, five to seven feet in height, and face due south. Near Buteland House there are six to seven terraces, three feet in height, and many yards in breadth, facing west. Those near Birtley form nearly a rectangle, the western face being 300 yards long, the southern face 110 yards. The former has six ledges, with a shorter one inserted midway, and the lowest not parallel. The terraces average three,

* Part i., vol. iii

five, six, seven, one-and-a-half, and five feet in height, reckoning from the base; and the platforms are fourteen, eight, and the three uppermost, nine yards in breadth. The peculiarity of these ridges, as compared with ancient river-terraces, is their want of parallelism, their disagreement in relative levels, and their general want of correspondence with the course of the valley, as well as the fact that one set of terraces disagrees with another near it. Mr. Hall cites the opinion of Mr. G. Tate, F.G.S., in favour of the artificial, and *against* the geological origin of these terraces. He refers to the various theories as to the military uses to which they may have been applied, and cites Lieut. Sitwell, R.E., against their fitness as lines of defences. Finally, from independent investigation, the author has been led to the conclusion that we have here the early attempts at cereal cultivation of the ancient British inhabitants of the valley.

The author cites numerous authorities, both ancient and modern, in favour of his theory, and we are bound to say he makes out a good case. Mr. G. Poulett Scrope has given this explanation to terraces in Wilts and Dorset, and shown that these "Linchets" or "Balks" are still in process of formation on farms in Wiltshire at the present day.*

In the 'Transactions and Proceedings of the New Zealand Institute,'† there is, among other interesting matter, a paper by the Hon. W. B. Mantell, F.G.S., on the "Moa."

After instancing examples to show that New Zealand was not peculiar in the circumstance that huge birds, without the power of flight, were the highest form of life previous to the arrival of man in the islands, he proceeded to describe the different circumstances under which the remains of the Moa are found, assigning the highest antiquity to those that are found under the stalagmite in certain limestone caves similar to the bone-caves in which traces of the early animals which inhabited Great Britain are preserved to us. He drew attention to the fact, that in the British caves, among the great variety of animals represented, there is always evidence that they were dragged into these caves by beasts of prey; but New Zealand caves have failed to show any such cause for the presence of the Moa-bones in them, or that any animal existed beyond larger forms of those now inhabiting the islands. These cave Moa-bones, and probably those found in certain alluvial deposits, he considered to belong to a period before the arrival of the aborigines. He then described the several circumstances under which the remains of the Moa are found associated with works of man, in such a manner as to leave no doubt that they co-existed with the earliest aborigines, and were largely used as food, along

* See 'Geol. Mag.,' vol. iii., 1866, p. 293.
† Vol. i. (issued May, 1869).

with seals and a variety of other animals. From the examination of the *umus* or Maori ovens, there was evidence that cannibalism prevailed at the time the Moas were used for food, but only in the North Island. Certain works of art associated with bones in these early deposits appear to indicate a period when many of the implements in common use among the Maoris, and supposed to have been brought with them from Hawaiki, were unknown to these early aborigines. The highly-prized Ponamu, or Greenstone, appears also to have been discovered in New Zealand at a later date. The most ancient of the native ovens which he had examined were scooped out in the surface of marine deposits, generally blue-clays or sands, such as are deposited in estuaries or tidal lagoons, and never covered by other than fresh-water or blown sand deposits.

Those at Wainongaro, in the North Island, and at Awamua, in Otago, were the oldest he had seen, and contained fragments of stone used as cutting implements, of kinds that showed that even at that early period the natives had extensively explored the interior of these islands. In Otago, especially, it is probable that the interior was their usual dwelling-place, and that they only paid occasional and periodical visits to the sea-coast. He referred to certain rude figures which he discovered drawn on the walls of a cave in the Waitaki valley, among which was rudely depicted the likeness of a Moa, by some early aboriginal artist, and proceeded to describe the causes which led to the extermination of those birds. This must have taken place within a very short period after the appearance of man, adducing the very slight and obscure allusions in the most ancient Maori traditions to their existence as proof of this.

After alluding to the probable habits and mode of life of the Moa, and to the present representatives of the class of bird to which they belong, Mr. Mantell concluded by saying that in his lecture he confined himself to the subject of the Moa, the native word including these birds as a whole, leaving the different species of *Dinornis*, *Palapteryx*, and other genera which have been made, to those who believe that they have the necessary data; for his part, he did not believe that, with the exception of the very fresh skeleton found in Otago, and now in the York Museum, of which the integument and feathers are partly preserved, there was yet a single skeleton restored in such a manner as would be at all suited to the wants of the bird if it were alive; he therefore strongly urged the careful collection of specimens, and that those persons who discovered bones, if they did not consider themselves well acquainted with the subject, should leave them untouched until they could be exhumed by properly qualified collectors.

In Dr. Foster's 'Mississippi Valley,'* the author gives an

* P. 415

account of the extent and distribution of the relics of the ancient "Mound-Builders," a race which, long antecedent to the North-American Indian, once occupied the region of the Great Lakes and the Valley of the Mississippi. The trees which covered these mounds when first discovered by the white settlers, differed in no degree, either of size or form, from those of the surrounding woods. The late Professor Hitchcoc', without examination, denied their artificial origin, but subsequent investigations by the geologist and the antiquary, side by side, have proved beyond a doubt that they were formed by human hands. Evidence afforded by the earth-works has also connected their builders with the ancient copper-miners of Lake Superior, whose operations represent probably the most extensive pre-historic mines in the world.

Dr. Foster points out that the number and magnitude of these earth-works not only indicate a vast population, but also a people subsisting by agricultural pursuits; as no mere nomadic race, subsisting by the chase, could have devoted the time necessary for the formation of such extensive national works. The earth-work at Cahokia, Illinois, is 90 feet high, and has a base of 666 feet; while the famous mound at Grave Creek, Virginia, is 70 feet high, with a base of 333 feet; and the next in rank is that of Miamisburgh, Ohio, which is 68 feet high, with a base of 284 feet.

Near Newark, Ohio, the circles, squares, parallel roads, and tumuli, extend over many leagues of ground, and out-rival, in cubical contents, the great Pyramid of Cheops.

Their weapons were spear and arrow heads, chipped with much skill, out of hornstone or chert; hammers, generally of porphyry, grooved near the head for the attachment of a withe; fleshing instruments of the same material, brought down to a blunt edge; pestles for cracking and grinding corn; plates of steatite, or chlorite slate, pierced with holes to gauge the size of the thread in spinning; circular discs, like weights, and concave on both sides, ordinarily of porphyry and ground; ornaments like plum-bobs, double-coned, or egg-shaped, and pierced or grooved at one end for the attachment of a string made of specular iron, like that of Lake Superior; lastly, elaborately-wrought pipes, showing that they indulged in the luxury of tobacco.

They mined extensively the native copper on the shores of Lake Superior, and wrought it into knives, spear-heads, chisels, bracelets, and other personal ornaments.

They were unacquainted with tin, and had no alloy; and there is reason to believe they did not, even ordinarily, smelt the copper, but simply *hammered it cold.*

Bracelets of copper have been found in the mounds, enclosing native silver in the unaltered state as it occurs in the mine.

They had also made considerable advance in the ceramic art,

many of the specimens of pottery discovered displaying considerable taste and skill.

Dr. Foster concludes that the Mound-Builders were an industrious, peaceful, and numerous race, pursuing agriculture as a means of support, maize being their staple article of food; ruled over by a despotic government, under whose direction their great public monuments were carried out; and lastly, that their extermination has resulted from the invasion of a less civilized but more vigorous and warlike people.

3. ASTRONOMY.

(Including the Proceedings of the Astronomical Society.)

The successful observation of the eclipse of August 7th is a fortunate circumstance for science, because it is not likely that either of the two next total eclipses (in 1870 and 1871) will afford a favourable opportunity for observations of the coloured prominences. The eclipse of 1872 will last but a few seconds as a total eclipse, and will only be visible as such over parts of the South Pacific.

The observations made by the American astronomers leave little to be desired. The photographs which have been obtained will probably be the best which have hitherto rewarded the exertions of astronomers in the particularly difficult art of celestial photography. Major Tennant at Guntoor, and the German observers at Aden, last year obtained remarkably good photographs of the eclipsed sun; but the intense heat of the Indian climate added largely to Major Tennant's difficulties, while the observers at Aden had to photograph the prominences soon after sun-rise, when their light was received through the denser atmospheric strata. In the United States all the circumstances were highly favourable; and from the known skill of the American astronomers in the art of celestial photography, we may hope for results of the utmost importance and scientific value. It is seldom that an eclipse visits astronomers so near their own home as this one did, its track lying close past several of the leading American observatories.

The most interesting result of the observations, so far as our information as yet extends, is the discovery that the spectrum of the prominences contains several lines more than had hitherto been discovered. M. Rayet last year discovered eight, but some doubt was thrown on his observations by the fact that none of the other astronomers engaged in the spectroscopic analysis of the prominences saw so many lines. Professor Winlock, observing the recent eclipse at Shelbyville, Kentucky, saw no less than eleven bright lines.

Thus we may infer that the structure of the prominences is more complex than had hitherto been supposed. It is to be hoped that the new lines, and possibly others, may admit of being rendered visible by the spectroscope without the aid of an eclipse. Possibly when Mr. Huggins' new telescope is at work, we may learn the position of the newly-discovered lines in the accurate manner which the particular mode of observation we refer to renders possible. It would be interesting to discover what are the elements to which the lines belong.

The darkness during the eclipse was much greater than during the eclipse of last year, though the totality did not last so long by nearly three minutes. Some of the observers searched, but without success, for intra-Mercurial planets.

Although Professor Tyndall's recent investigations of the phenomena presented by comets are too closely associated with his physical researches to be described in full in our astronomical Chronicle, yet there are certain points connected with his new theory which it belongs especially to astronomy to deal with.

Passing over the physical considerations on which the theory depends, and which serve to distinguish it from most of the hypotheses hitherto put forward (based as these are on no known experimental laws), we may describe the theory as follows :—

The tail of a comet is not matter projected from the head, but matter precipitated on the solar beams which have traversed the head. Tyndall has shown that such precipitation may occur either with comparative slowness along the beam, or with the velocity with which the beam actually traverses space. Thus the amazing rapidity with which a comet's tail is sometimes developed is accounted for "without invoking the incredible motion of translation hitherto assumed."* As the comet sweeps round the perihelion, the tail is not composed of the same matter, but new matter is precipitated on the solar beams, the part of the old tail which is not protected (so to speak) by the head of the comet being dissipated by the sun's calorific rays; and the dissipation not being necessarily instantaneous, "the tail leans towards that portion of space last quitted by the comet—a general fact of observation being thus accounted for." Occasional lateral streamers are explained as possibly due to the temporary mastery of the actinic rays in parts of the cometary atmosphere not screened by the nucleus. Lastly, the shrinking of the head as the comet approaches the sun is due to the beating of the heat-rays against the attenuated fringe of the head, which is thus dissipated.

Although the theory, as at present put forward, fails to account

* Here, in passing, we may notice that Professor Tyndall is in error as to the opinions received among astronomers, for Sir John Herschel long since proved that no such assumption is permissible.

for many of the observed peculiarities of comets, yet it appears to us not unlikely that a way may yet be found to reconcile the strange phenomena which some comets have presented with the views maintained by Professor Tyndall. We cannot at present admit his explanation of lateral streamers, because it leaves us in quite as much perplexity as we have ever been in with respect to this strange phenomenon. When we see a tail extending in a right line from the head, but at an angle of 60° or so to the radial line from the sun, we require more to account for the peculiarity than the bare possibility that along that line the actinic rays may temporarily have obtained the mastery; and when we see, as in the famous comet of 1774, six distinct tails spreading from the head in the shape of a fan, it is yet more unsatisfactory to refer to a mere possibility of this sort. Professor Tyndall mentions no illustrative case as having occurred in the course of his experiments on actinic clouds; and therefore, so far as this part of his theory is concerned, he seems scarcely justified in saying that "throughout he has dealt exclusively with true causes," and that "no agency has been invoked which does not rest on the sure basis either of observation or experiment."

However, the great difficulty in cometic phenomena, the apparent swinging round of the tail with a velocity often far exceeding the greatest velocity *possible* within the solar scheme, is undoubtedly mastered by Professor Tyndall's theory; and this circumstance renders us hopeful that he may be able to find a more satisfactory explanation than he has yet given of *abnormal* cometic phenomena.

The application of the enormous heat-gathering powers of the great Parsonstown reflector to the solution of the long-vexed problem of the moon's heat, is one of the most valuable results which have followed the construction of clock-work suited to drive this great telescope. The question is one of such extreme delicacy, that so long as the telescope had to be guided by the old arrangement no results of a satisfactory nature could be hoped for. On the other hand, no other telescope could be applied to the work with reasonable chance of success. Mr. Huggins had detected no sign of heat, when the moon's rays were gathered by his powerful refractor upon the face of a delicate thermopile; and indeed Professor Tyndall long since pointed out that it was almost hopeless to apply a refractor to such work, the moon's heat being of such a nature that far the greater part must be absorbed by the object-lens. With the Rosse telescope (used in combination with a delicate thermopile), clear signs of heat were detected, and thus at length the question has been set at rest.

Comparing the heat received from the moon with that derived from several terrestrial sources, Lord Rosse has deduced the conclusion that at the time of full moon a part of the moon's surface

may be heated to a temperature of more than 500° Fahrenheit. We have no particulars, however, as to the reasoning which led the observer to the conclusion that most of the heat we receive from the moon is radiated towards us. May not the majority have been reflected? The distinction is all-important, so far as the views we are to form of the temperature of the moon's surface are concerned.

The planet Jupiter will be well placed for observation during the next quarter. Saturn is passing away from our skies.

Judging from the wide region over which the November meteors were seen last year, there is every reason to believe that they will be well seen in England this year, on November 14th, in the morning hours, though probably the shower will not be comparable with that of 1866.

Proceedings of the Astronomical Society.

Mr. Plummer has been able to confirm Mr. Huggins' spectroscopic observations of the Auroral streamers. He notices that the line in the Aurora spectrum agrees closely with the most conspicuous of the lines in the spectrum of Betelgeux, between the solar lines D and E. There is also a tolerably conspicuous line in the spectrum of Aldebaran near the same place. A conspicuous line in the spectrum of air is near the line seen in the spectrum of Aurora, but not near enough, in Mr. Plummer's opinion, to suggest the possibility that the want of coincidence is due to an error of observation.

Mr. Plummer noticed further that Winnecke's comet was visible with the 6½-inch refractor of the Durham Observatory, through one of the densest streamers, "without any other inconvenience than that of the brightness of the field of view.

Commander Ashe, R.N., sends an interesting account of his determination of the position of "Rivière du Loup," by electric telegraph. The place is about 130 miles below Quebec. Commander Ashe took advantage of the intense cold then prevailing in Canada, to obtain a firm stand for his transit instrument. He got a flour-barrel, removed the snow from the earth, and placed the barrel on the ground, then filled it with sand, poured two or three buckets of water over it and around it, and, as it was freezing, placed a square piece of board on the top. In a few minutes the whole was a solid mass, and throughout the series of observations this novel observatory continued firm and unshaken. His work was somewhat impeded by the Canadian boys, "who are of the English type," and therefore are unable to resist their propensity for throwing stones when they see a light; "and it is impossible to count seconds under these circumstances," adds Commander Ashe.

The deduced longitude of Rivière du Loup is 4 h. 38 m. 10·295 s.

An account of the recent transit of Mercury, as seen at Vizagapatam by Mr. A. V. Nursing Row (a Hindoo astronomer), contains some points of interest. Mr. Row and some of his friends noticed that near the middle of the transit a "wavy tint of light" darted from the upper edge of the planet. The light was occasionally disturbed, but continued visible for some time. No change of focal length or of the eye-piece employed had any effect on the phenomenon. We do not remember any instance of a phenomenon of this sort having been noticed before during a transit of Mercury. As the Astronomer Royal for Scotland remarks, it is not easy to explain the significance of so peculiar a feature.

Major Tennant supplies an interesting note on the preparations desirable for photographic observations of such phenomena as transits of Venus. He believes that this method of utilizing a transit is a very valuable one, though he considers that it should be subjected to trial before being unreservedly trusted. He remarks that a reflecting telescope with *unsilvered* glass mirrors would give comparatively little light; and still less if the image were optically enlarged. This point is of importance in connection with the question of instrumental distortion. In a Newtonian telescope, a convex or concave lens achromatized for the actinic rays might be used; or the telescope might be a Cassegrainian, an arrangement which would be more compact than the other. An "instantaneous shutter" would allow a fairly large aperture to be used, and "this having its centre-part removed would give good definition." He suggests a new mode of releasing the shutter. At Kew it is held against a spring by a thread which is cut with scissors. Major Tennant proposes that it should be retained by an electro-magnet, and that the current forming this should pass through a chronograph. Thus if an observer at a separate telescope had a break-circuit key, he could at any moment photographically record a phenomenon he saw and the instant of its occurrence.

Mr. De la Rue, remarking on Major Tennant's paper, expresses his preference for a Newtonian reflector; the heat emerging from the back of the principal mirror, when either the Cassegrainian or Gregorian forms are used, would seriously interfere, he remarks, with the success of photographic manipulations.

Both papers show the importance of a complete investigation of all the circumstances of the coming transits.

Major Tennant suggests that preparations should be made for observing the total eclipse of 1871 in the south of India. He does not comment upon the nature of the eclipse, which we should have thought little suited for the sort of observations he suggests. In South India the totality will last little over two minutes.

Mr. Baxendell discusses the nature of the corona seen round

the sun in total eclipses. He considers that the view taken by M. Faye and the Astronomer Royal (who look upon the corona as an atmospheric phenomenon) is wholly inadmissible. When "the corona is seen to the greatest advantage, no part of the earth's atmosphere within a considerable angular distance of the sun and moon receives any direct sunlight, and therefore none can be reflected from it." He considers that not merely the optical phenomena of the corona, but "an immense number of magnetical and temperature observations made in different parts of the world" can be best explained by assuming the existence of an irregular nebulous ring circulating about the sun nearly in the plane of the ecliptic, and at a mean distance of ·169.

Mr. Joynson has presented another series of drawings of Mars to the Society. They are selected from ninety made at various times during the recent opposition of the planet. The planet has been so carefully scanned by the late Mr. Dawes, with his fine 8-inch refractor and his unsurpassed powers of vision, that one can hardly imagine what useful object an observer can propose to himself in laboriously depicting the planet as it appears under far inferior powers. Nothing but a very powerful telescope can now teach us anything new about the lands and seas of Mars.

Professor Loomis shows that Mr. Tebbutt's observations of the variation of the mysterious star η Argûs may be explained by assigning to the star a period of variation of sixty-seven years, instead of the period of forty-six years obtained by Professor Wolf. According to this view, the star has now reached its true minimum of splendour, and we may probably soon expect to see it steadily increasing. According to the best observations during the past century, the star has no less than three distinct maxima of splendour —two nearly equal and corresponding to a brightness exceeding that of all stars but Canopus and Sirius, the other corresponding to the least brilliancy of a first-magnitude star. The variable has but one minimum, corresponding to a brightness somewhat less than that of a sixth-magnitude star.

Mr. Browning describes a large sun-spot which was visible on March 14th, 1869. From north to south the spot measured 14,400 miles; from west to east 19,600 miles. The umbra contained three nuclei of very unequal dimensions, arranged nearly in the form of an equilateral triangle. Two bridges crossed the spot at an angle of about 40°. These bridges presented the appearance of broken twigs, lying mostly in the direction of the bridges' length.

On May 13th, Mr. Bidder saw a spot having a bridge of an unusually attenuated shape, and spirally formed.

Major Tennant suggests certain modifications in the construction of spirit-levels. He considers that the volume of the bubble

should be large, that its density relatively to that of the fluid should be small, and that the surface common to the fluid and the bubble should have as large an area as possible. To gain these points, and to cause the temperature to have as small an effect as possible upon the length of the bubble, he proposes that the cylindrical form of level should be abandoned, and the necessary cavity be cut out of a rectangular prism of glass. He suggests mercury for the fluid and hydrogen for the bubble.

Mr. Hind supplies an important note respecting the transit of Venus in 1874. M. Puiseux, who had independently calculated the circumstances of the transit, had arrived at results somewhat different from those published by Mr. Hind in 1861. Mr. Hind has placed the re-calculation of the elements in the hands of Mr. W. Plummer, his assistant at Mr. Bishop's observatory, Twickenham, and the result is that Mr. Hind's estimates are confirmed in a most satisfactory manner.

The June number of the Monthly Notices was not published by the Society's printers until the middle of August, nearly six weeks after the proper time. It contains six large maps by Mr. Proctor, illustrating a paper on the transit of Venus. Of these, four represent the same features which had been exhibited in the Astronomer Royal's maps accompanying the December number of the Notices, and show the effects of changing the phase from the passage of Venus's centre to the planet's internal contacts. The other two are enlarged drawings of the features exhibited in our last number. The corrections resulting from the former set are new, and some of them, if established, would seem to be important. Thus Crozet Island, which had been rejected on account of the low elevation of the sun there at ingress, is shown to have the sun $5\frac{1}{2}$ degrees higher than had been supposed. The calculated solar elevation of $4\frac{1}{2}$ degrees at Bourbon Island is altered to $12\frac{1}{2}$ degrees; 6 degrees at Mauritius to 14 degrees; and $11\frac{1}{2}$ degrees at Rodriguez to 19 degrees. These numbers all refer to ingress. As respects egress, the most important change is from a calculated solar elevation of $11\frac{1}{2}$ degrees at Chatham Island to one of 16 degrees. A number of Indian stations before unnoticed are shown to be among the best available places for observing the retarded egress.

Professor Brayley supplies an interesting paper on the nature of the bridges of light seen across solar spots. He looks upon these as the upper termination of vorticose flames.

Mr. Stone gives a table of the probable errors of Greenwich observations in zenith distance, estimated merely by their discordances from the separate means. More than 2000 observations were employed in obtaining the errors. The probable error ranges from $0''\cdot47$ at the zenith to $0''\cdot60$ half-way between the zenith and the horizon; thence to $0''\cdot70$ at an elevation of 35° above the

horizon; to 0″·80 at an elevation of 25°; to 0″·95 at an elevation of 15°; 1″·20 at 10°; 1″·92 at 5°; and, finally, 3″·32 at 3° above the horizon. These results are of the utmost importance in relation to the probable correctness of the proper motions assigned to stars which do not rise high above the horizon of Greenwich.

Mr. Browning describes a remarkably simple form of star-spectroscope. It is for direct vision, and weighs only about 7 ounces, *or much less than an ordinary micrometer*, so that it will scarcely at all affect the balance of a telescope.

4. BOTANY AND VEGETABLE PHYSIOLOGY.

The Antheridia of Ferns.—Dr. Kny, of Berlin, records some interesting observations on the development of the Antheridia in Ferns, which has hitherto received several distinct explanations, in spite of its apparently simple character. Cells of the form of closed rings have hitherto been observed only in the full-grown frond of several species of *Aneimia.* Concerning the mode of their formation there is a difference of opinion, at present unreconciled, between Hildebrand and Strassburger; but both these authorities agree in this, that the ring-cells have not been originally produced as such, but have received their peculiar form as a secondary development. In the antheridia of some species of *Polypodiaceæ* and *Schizæaceæ*, Dr. Kny has observed, as he thinks, the first example of a direct origin of ring-cells by the formation of funnel-shaped separating walls. They show at the same time that this occurrence, hitherto entirely isolated in the vegetable kingdom, admits of two modifications; since the ring-cells are separated in the one case from a hemispherical, in the other case from a bell-shaped mother-cell. Dr. Kny promises further researches in this interesting field.

Reproductive Organs of Lichens.—According to M. Famitzin, the Gonidia of Lichens—that is, the spherical cells filled with chlorophyll which are dispersed in the parenchyma of the frond—if maintained in a condition of sufficient humidity on the surface of bits of bark during several months, will give rise in their interior to zoospores; that is, to uniform corpuscles provided with definite movements by vibratile cilia like the zoospores of Algæ.

Spectroscopic Examination of Diatomaceæ.—Mr. H. L. Smith* has confirmed the vegetable nature of Diatoms by the application of the spectroscope. He has proved the absolute identity of chlorophyll or the green endochrome of plants, with diatomin or the olive-yellow endochrome of the diatoms, by the identity of their spectrum, which is a very remarkable one.

* 'American Journal of Science and Arts.'

Fertilization of Gramineæ.—M. Bidard has been observing the fertilization of grasses. He states that their pollen does not exhibit any trace of pollen-tubes, and that self-fertilization takes place before the anthers are extended beyond the perigone. The fovilla is itself absorbed from the pollen after it falls on the stigma through the thread-like tubes which perforate it. There exist in grasses two principal phenomena which are only known as belonging to this family,—the elongation of the filaments and their extrusion from the perigone after fertilization has taken place, and the fecundation by perforation of the pollen. The heat of the breath or a ray of sunshine is sufficient to bring about the phenomena of fecundation; and the natural hybridization of grasses is impossible, owing to the exact closure of the chamber containing the fecundating organ.

Fertilization of Salvia.—A contribution towards the investigation of the phenomena attending the impregnation of plants has been made in the case of the genus *Salvia*, affording a striking instance of the natural tendency towards cross-fertilization which Mr. Darwin has pointed out. The two perfect stamens of *Salvia* contain each two anther-cells at the opposite ends of a connective which is longer than the filament itself. The arm of the connective to which the upper anther-cell is attached is longer than that which supports the lower anther-cell, this latter being in some species entirely, in others partially, destitute of pollen. The lower anther-cell projects far into the mouth of the corolla, so that when the flower is visited by the bees, which frequent it very freely, the insect necessarily pushes it aside, and causes the extremely mobile connective to rotate; the upper anther-cells thus emerge from the hooded receptacle in which they are hidden, so as to bring their dehiscing surfaces into contact with the bee, one on either side. The stigmas are not ripe till a considerably later period than the anthers, and the style being prolonged much beyond the upper anther-cells, these cannot in their rotation strike against the stigmas, nor does the bee strike them in retiring from the flower. At a later period of development, however, the style becomes bent down, so that the stigmas block up the entrance into the mouth of the corolla, and it is only at this period that the stigmatic surface becomes fully developed. When a bee laden with pollen enters a flower in which the style has assumed this position, it cannot fail to rub its back against the stigmatic surface, and thus secure the fertilization of the flower. This structure has been observed, with slight modifications, in *Salvia officinalis, glutinosa, pratensis, Sclarea*, and some other species.

Effects of Smoke on Vegetation.—Mr. E. Green, gardener to the Right Hon. J. W. Patten, M.P., of Warrington Hall, read at the Manchester Congress an article on this subject, which contains some useful hints for dwellers in towns. During the last twenty years

the smoke and noxious gases from the chemical works have greatly increased, and one plant and tree after another has succumbed to their baneful influence. Of forest trees and shrubs, the fir and the larch were the first to give way; then followed the *Cotoneaster macrophylla*, arbor-vitæ, juniper, Erica, and rosemary. *Berberis ilicifolia*, yew, rose, and holly are disappearing, and none of the Conifers will live more than two or three years. The sycamore and hornbeam are decaying fast; the horse-chestnut is vigorous, but the leaves are often cut by the noxious vapours; beech and lime are more healthy; ash and elm the most vigorous. Rhododendron, Aucuba, and hawthorn flourish; the oak does very well; laburnum, Syringa, willow, birch, ivy, and elder are still healthy, and the privet moderately so. Of fruit-trees the pear stands best; plum and damson moderately well; apple suffers much; also red and white currant; raspberry and gooseberry rather better, but the fruit much deteriorated in flavour. Of vegetables which do well in the summer-months, kidney-beans sometimes drop off early in October; cauliflower and broccoli do not stand any frost; and even the common winter greens are very frequently injured by the cold; cucumbers cannot be grown. One effect of the gases from the chemical works is to make vegetation far more susceptible to cold; the trees, even when healthy, cast their leaves six weeks earlier than in the country districts. The greatest amount of injury occurs when the atmosphere is heavy and foggy, with scarcely a breeze; the young foliage being sometimes found cut and blackened in a straight line, as if by frost; when the wind is from the west it does more damage than when in the east.

Action of Ether on Plants.—Dr. Masters states that if a drop of ether is placed gently on the leaves of the sensitive plant, *Mimosa pudica*, it produces an anæsthetic or paralyzing effect, rendering them insensible to subsequent contact. If, however, the ether impinges on the leaf with force, or is allowed to drop from a considerable height, contraction of the leaf immediately ensues, the impact of the falling drop counteracting any paralyzing power. Experiments of a similar kind on other plants resulted in the death of the leaf or of the whole plant, or in causing the leaf to curl up along its under-surface.

Anniversary Address to the Linnean Society.—The usual anniversary address by Mr. Bentham, the President of the Linnean Society, was distinguished by the declaration of the adhesion of the first English systematist to the principle of the derivative origin of species, and the close connection between affinity of structure and consanguinity of descent. The portion of the address devoted to botanical science was chiefly occupied by a discussion of the means of dispersion of plants, the theory of stores of buried seeds, and the characteristics of dissevered species.

Mr. Bentham believes that too much stress has been laid on the structural appliances for the dissemination of seeds, and too little on the external means of transportation by birds, &c. Among *Compositæ*, several species of *Eclipta*, *Elephantopus*, *Anthemis*, and *Lapsana*, the fruit of which is destitute of pappus, have a much more wide-spread distribution than the great majority of *Senecios*. A large proportion, too, of the thistle-down which is seen floating in the air will be found on examination to have lost its seeds. It is calculated that out of every 100,000 seeds of the wild foxglove, 99,999 must perish before reaching the reproductive age. The usual explanation of the sudden appearance of new species in localities where they were hitherto unknown, on an alteration in the condition of the soil, is De Candolle's statement, "Il faut donc regarder la couche de terre végétale d'un pays comme un magasin de graines au profit des espèces indigènes." This supposition appears to rest entirely on circumstantial evidence, where direct evidence ought to be easily attainable. Though the seeds of plants which thus suddenly appear in great quantities are often by no means microscopical, as in the case of the white or Dutch clover, there is no record of a single instance in which these stores have been actually seen. Nor is there any satisfactory evidence that seeds will retain their vitality for any considerable length of time unless kept perfectly dry. Mr. Bentham would be more disposed to account for these sudden appearances by the rapid transportation of seeds by birds and other means than by the ordinary theory of stores buried in the ground for an indefinite period.

Preservation of Sub-tropical Plants through the Winter.—The mild winter of 1868–69, following closely on the remarkably fine summer of 1868, was favourable to the preservation of half-hardy plants through the winter. In the gardens of Battersea Park a number of such plants and shrubs have now been preserved for several winters by a covering of dry litter or other loose non-conducting material sufficiently thick to exclude frost. Under this treatment *Canna peruviana* and *expansa* have been preserved for two years; *Aralia papyrifera* and *Solanum laciniatum-elegans* survived last winter; while a variety of the rice-paper plant, *A. Sieboldi*, has lived through five winters, and *Echeveria secunda-glauca* has withstood 22° of frost.

Sources of Copal.—Mr. Jackson, the Curator of the Museum at Kew, has been investigating the sources of copal, an article well known to commercial men, but the origin of which has been imperfectly ascertained by botanists. Several sorts of copal are known in British trade, as the Brazilian, Indian, African, &c., the product of widely different plants. Dammar, or East Indian copal, is said to be the produce of *Vateria indica*. *Dammara orientalis* and *australis* (Coniferæ) also furnish copal from Moluccas and

Australia; while the Indian dammar is thought to be produced from *Canarium strictum* and *Shorea robusta*, and Brazilian copal from several species of *Hymenæa*. *H. coubaril* is a well-known tree in the West Indies, Brazil, Guiana, &c., exuding large quantities of a clear copal-like resin, and is probably one of the chief sources. The fruit and bark of *Trachylobium mossambicense* also contain it in large quantities, and this appears to be the source of the Zanzibar copal, and of the half-fossilized resin known in English commerce as anime. The quantity of copal exported from Zanzibar has been known to amount in some years to 800,000 lbs., valued at 60,000*l*. The fact of insects and other foreign substances being found imbedded in copal, whether recent or fossil, is easily accounted for. The tenacity of the resin when in a semi-fluid state readily entraps all bodies coming in contact with it, and it then rapidly hardens; and considering that the resin flows from the under-side of the principal branches, the fruit, flowers, or twigs of the under-growth or lower vegetation would be likely to be caught by the exuding resin and so preserved, rather than the heavy, glossy foliage of the tree itself.

Flora of the Sandwich Islands.—The flora of this group of islands was carefully investigated by the late Mr. Mann. They have a surface of about 4000 square miles, situated just within the tropics, and more than 1000 miles from any other land, except a few rocks lying to the north-west, bare of vegetation, and inhabited only by sea-fowl and seals. On this area, which includes an excessively dry and hot, a very wet and hot, and every other variety to a very dry and cold climate, is found a flora of 620 native species of flowering plants (omitting *Gramineæ*, which have not yet been fully studied) and ferns, of which the former comprise 485, and the latter 135 species. Of the 554 flowering plants, including 69 species known or supposed to have been introduced, 479 belong to *Dicotyledonæ* and 75 to *Monocotyledonæ*; and they are divided among 253 genera and 87 natural orders. Of the 554 species 377 are peculiar to the group, while 42 are of recent and 27 of supposed aboriginal introduction. Of the 253 genera 39 are peculiar, and these 39 genera are represented by 151 species, or 3·94 species to a genus, while the whole flora has but 2·58 species to each genus, thus showing the important part taken by these genera in constituting the whole phænagamous flora.

Flora of Manbhúm.—Mr. V. Ball has turned his researches connected with the Geological Survey of India to account for the benefit of botanical science, by investigating the flora of the district of Manbhúm, no collection having previously been made of the plants found in its southern portion. Instead of meeting with a realization of one's ideal of a tropical jungle, the effect produced by the vegetation is, in many parts, not strikingly different from

what we are accustomed to in England, from the park-like aspect which prevails in the higher and clearer portions; even in the valleys there are no tree-ferns nor palms, and but few orchids, mosses, or herbaceous ferns. The water and bog-plants, in particular, belong largely to European genera, as *Nymphæa, Drosera, Potamageton, Alisma, Cyperus, Scirpus*, &c.; while the forest-trees are entirely different. Mr. Ball enumerates between thirty and forty of these, the timber of which is more or less valuable.

Lichens of New Grenada.—MM. Triana and Lindig have brought up the number of species of lichens in New Grenada to 467, of which 98 belong to the European flora. The saxicole species are generally more cosmopolitan than the terrestrial or corticole species; according to Nylander a large number of the European saxicole lichens inhabit also, in the tropics, the summits of mountains, while the terrestrial or corticole species are almost always more characteristic of the cryptogamous vegetation of the country which they inhabit. From New Caledonia, Dr. Nylander announces 220 species of lichens.

The Palms of Equatorial America.—Mr. R. Spruce publishes, in the 'Journal of the Linnean Society,' the results of his researches among the palms of Equatorial South America during the years 1849–1860, between 7° South and 5° North latitude, including descriptions of a large number of species not found by Martius or Wallace. Mr. Spruce's investigations of palms have led him to the somewhat singular conclusion that the hermaphrodite and self-fertilizing structure of plants is an earlier development, which has gradually advanced to the higher type of unisexuality.

Botanical Exchange Club.—In the Report of the London Botanical Exchange Club for 1868, Mr. Boswell-Syme includes much information interesting to the collector of British plants. Messrs. A. G. More and C. Bailey record the appearance of *Scirpus parvulus* on mud flats, at the mouth of the river Avoca, in co. Wicklow. The only previously recorded British habitat was near Lymington, in Hampshire, where it was believed to be extinct. *Aster salignus*, previously recorded by Miss Edmonds, from the shores of Derwentwater, appears to have been observed in that locality for the last thirty years. Mr. Boswell-Syme has revised his sub-division of *Ranunculus aquatilis*, as given in 'English Botany,' and now makes only two sub-species, *R. peltatus* and *stenopetalus*, the former including the forms *vulgaris, floribundus*, and *pseudo-fluitans*, the latter *heterophyllus, Drouettii*, and *trichophyllus*. *Mentha Nouletiana*, sent from Gloucestershire by Dr. St. Brody, appears exactly intermediate between *M. sylvestris* and *viridis*. Mr. H. C. Watson has established that the so-called *Chenopodium pseudo-botryoides* is nothing but an accidental form of *C. rubrum*. *Potamageton filiformis*, not previously recorded from Fife, has

been detected in great abundance by Mr. Boswell-Syme, in Loch Gelly and Camilla Loch. Mr. H. C. Watson and Rev. W. W. Spicer record *Wolffia (Lemna) arrhiza* in several fresh localities in Surrey. *Phegopteris plumosa* (J. Smith) from Kew Gardens, originally from Yorkshire, is pronounced by Mr. J. G. Baker to be nothing but a very delicate finely-cut form of *Athyrium Filix-femina.* We are glad to observe that the number of members of this useful society has considerably increased during the last two years.

Botanical Appointment.—Mr. J. G. Baker, Assistant-Curator at the Kew Herbarium, has been appointed Lecturer on Botany at the London Hospital, in the place of Dr. Silver.

Death.—Dr. Chas. Jas. Meller, Director of the Botanic Gardens at the Mauritius, the companion of Dr. Livingstone in several of his journeys, died on the 26th of February, at the age of thirty-three, of fever, in New South Wales, while on a tour on behalf of the government of Mauritius, for the purpose of collecting information concerning the cultivation of the sugar-cane.

5. CHEMISTRY.

(Including the Proceedings of the Chemical Society.)

The new earth which we announced in our last Chronicles as having been discovered by Mr. Sorby, F.R.S., in some specimens of zircon or jargon, has been submitted to chemical examination by Mr. Forbes, F.R.S., who, as a result of this examination, has published a quantitative analysis of the specimen of jargon in which the discovery was first made.

The jargon employed was in fragments, being part of an almost colourless crystal, forwarded by Mr. Sorby, who had previously found, by optical examination, that it showed with great distinctness the peculiar and characteristic spectrum which he ascribes to the presence of the new element jargonium, and noticed that the bands became much more pronounced after ignition and cooling.

Space will not allow us to append the analytical processes employed; but we may briefly state that the result of the examination when summed up indicates the composition of the jargon to be as follows:—

Silica	33·61	
Zirconia α	46·12	66·28
" β (jargonia?)	7·64	
" γ "	12·64	
Sesquioxide of iron	·24	
	100·13	

The formula $Zr\ O_2$, $Si\ O_2$ ascribed to zircon requires:

Silicic acid	33·77
Zirconia	66·23
	100·00

with which the numbers found for jargon are closely approximative.

The results of this chemical examination must be considered as strengthening the evidence, physical and chemical, that the earth usually denominated zirconia is, in reality, a compound of two, if not more, closely allied oxides.

The details of an experiment, very important from a theoretical point of view, have been published by M. E. Drechsel; this is the reduction of carbonic acid to oxalic acid. Clean sodium is placed along with some sand in a clean flask, and a rapid stream of carbonic acid gas is passed into the flask, which, at the same time, should be heated to the temperature of boiling mercury; the metal assumes a purple colour, and after a few hours is converted into a dark pulverulent mass. After having cooled, the substances are withdrawn from the flask, and the mass is exhausted with water, the aqueous solution saturated with an excess of acetic acid and precipitated with chloride of calcium, whereby the salt, oxalate of lime, is obtained: 60 grms. of sodium yield, by this process, 6 grms. of pure oxalate of lime.

M. Boettger remarks that oxide of thallium inflames sulphuretted hydrogen when coming in contact with it; so do pure peroxide of manganese, peroxide of lead, and peroxide of silver obtained galvanically. With binoxide of barium, chlorate of lead, and chlorate of silver, the gas becomes vigorously inflamed; fulminate of silver also inflames the gas, and the salt explodes. Iodide of nitrogen explodes in contact with the gas, and gun-cotton is inflamed by it under certain conditions.

Dr. Matthiessen has succeeded in preparing, by the action of hydrochloric acid on morphia, a new base which is likely to be of considerable value from a physiological point of view.

Morphia is sealed up with a large excess of hydrochloric acid, and heated to 140°–150° C. for two or three hours. The residue in the tube contains the hydrochlorate of a new base, differing considerably in its properties from morphia. It may be obtained in a state of purity by dissolving the contents of the tube in water, adding excess of bicarbonate of sodium, and extracting the precipitate with ether or chloroform, in both of which the new base is readily soluble, whilst morphia is almost insoluble in both menstrua. This new base is called apomorphia.

When the hydrochlorate of apomorphia in a moist state is exposed to the air for some time, or if the dry salt is heated, it

turns green, probably from oxidation, as the change of colour is accompanied by an increase of weight. The base itself, newly precipitated, is white, but it speedily turns green on exposure to air. The green mass is partly soluble in water, communicating to it a fine emerald colour; it dissolves in alcohol, yielding also a green tint, in ether giving a magnificent rose-purple, and in chloroform giving a fine violet tint.

The physiological effects of apomorphia are very different from those of morphia: a very small dose produces speedy vomiting and considerable depression, but this soon passes off, leaving no after-ill effects. Dr. Gee is now studying these effects, and has found that $\frac{1}{10}$th of a grain of the hydrochlorate subcutaneously injected, or $\frac{1}{4}$ grain taken by the mouth, produces vomiting in from four to ten minutes. Mr. Prus allowed himself to be injected with $\frac{1}{10}$th grain, which produced vomiting in less than ten minutes. From Dr. Gee's experiments on himself and others, he concludes that the hydrochlorate is a non-irritant emetic and powerful anti-stimulant. From these properties it appears probable that it may come into use in medicine.

M. Hager observes that, although elementary chemical analysis of caffeine and theine yields results which would conclusively prove the identity of these two substances, yet the author found that the physiological effect, after partaking of a dose of ·25 grm. of both substances chemically pure, is by no means the same. The human organism is imbued with testing powers, compared with which chemical reagents are of little delicacy.

Dr. Hofmann has described a convenient method for the formation of ferric acid. An intimate mixture is made of one part of *ferrum limatum*, and two parts of nitrate of potassa; these are heated in a small glass flask over a strong gas flame; the mixture soon becomes quite incandescent, emits out of the mouth of the flask a firework of sparks, and leaves at last a mass partly fused into the glass of the flask, consisting of ferrate of potassium. After cooling, this mass is reduced to powder, and being exhausted with water, yields a deep-reddish violet-coloured nearly transparent solution.

Commercial chloroform is frequently adulterated with alcohol and ether, and it is sometimes of importance to ascertain whether these impurities are present in any given sample. In order to discover this, the chloroform should be first treated with fused chloride of calcium to eliminate any water; next some iodine must be added. If the chloroform is free from either alcohol or ether, the colour produced by the solution of the iodine is bright red; but when either alcohol or ether is present, the colour of the solution is brown. In order to distinguish between alcohol and ether, a

small piece of a crystal of fuchsine is added to the chloroform in question; when the slightest trace of alcohol is present, a deep-red solution will ensue. Perfectly pure chloroform yields, with fuchsine, a solution which is only slightly pinkish tinged.

In a long research on the subject of atmospheric ozone, M. Houzeau demonstrates that the air of the country is of a different character from that of towns; that the former is strongly disinfectant, has far greater bleaching power, and, especially after rainfall, affects bright and oxidizable metals far more than is the case in towns. In his paper the author calls attention to some facts readily observed—as, for instance, the rapid bleaching of all kinds of woven fabrics, be they made of linen, cotton, or woollen fibre; the rapid fading of very many dyed tissues; the far more active rusting of iron, steel, and even copper, in the country, as compared with large towns. Curiously enough the author does not mention the well-known fact of the effects of the air at sea, even at comparatively short distances from the shore, nor the peculiar effects produced by the mountain air at no greater height than from 2000 to 6000 feet above sea-level.

Oenoline is the name given by M. Morat to the colouring matter met with in genuine red wines obtained from grapes. It is obtainable by treating the wine by a very complicated process, and ultimately the colouring matter is precipitated as a red-coloured flocculent substance, insoluble in ether, very difficultly soluble in water, soluble in alcohol, and insoluble in benzol.

Professor Rochleder, of Prague, has found that when madder is treated with dilute mineral acids, it yields, besides alizarine and purpurine, a small quantity of a third tinctorial substance, which, in alkaline solution, has a great similarity to chrysophanic acid. This substance is soluble in alcohol and in acetic acid, and crystallizes from these solutions in orange-yellow coloured crystals; its aqueous solution, mixed with acetic acid and brought to the boiling-point, imparts to silk and wool immersed in it a beautiful and durable golden-yellow colour.

There is met with in commerce, under the name of Victoria yellow, or aniline orange, a reddish powder, which yields highly yellow-coloured solutions, and bears in general great likeness to the binitro-naphthol compounds. MM. Martius and Wichelhaus have instituted some researches on this material, and have found it to be a nearly pure binitro-cresol salt. The binitro-cresol they separated from it is readily soluble in alcohol, ether, chloroform, and boiling water. It may be obtained in crystalline shape. The dry substance fuses at about 110° C. The authors have tried in vain to obtain, by the experimental method, a clue to the mode of manufacture and

origin of this material. The solutions of binitro-cresol gradually become deep-red coloured on exposure to air.

M. Ponsard has applied Siemens's furnace to the manufacture of iron. He states that he has succeeded in producing 1 ton of cast iron, of excellent quality, with a consumption of only 1 ton of fuel. The author summarizes his results in the following manner:—1. A great saving of fuel can be made, and iron obtained from its ores without the use of the blast-furnace. 2. That, since the heat produced by flame is sufficient to effect all the chemical reactions and melt the metal, there may be used all kinds of fuel which produce gas—that is to say, all kinds of coal, no matter whatever their quality, wood, lignite, peat, hydrogen gas, and mineral oils. 3. It is possible to obtain, at will, a more or less carburetted metal, according to the quantity of carbonaceous matter which is mixed with the ore and placed in the crucibles to act as a chemical agent only. Specimens of iron, of very good quality, obtained by the process as carried on by the author, have been exhibited to the members of the French Academy.

The great solubility of protoxide of nitrogen in water, especially if its temperature is rather low, has induced M. S. Limnosin to try what the physiological effects of such a solution would be upon men and animals. The solution of the protoxide of nitrogen in cold water, obtained under ordinary pressure of the atmosphere, tastes decidedly saccharine, if by means of pressure water has been made to absorb a large bulk of this gas; as might be expected, this solution is readily decomposed by substances capable of taking up oxygen. The main point of importance in this paper is the anæsthetic action of the gas and solution alluded to.

M. Payen has taken the trouble to analyze a piece of old woodwork, once belonging to the well-known Chaillot pumps, in order to ascertain what state the cellulose was in after fully a century's exposure to wind and weather. By appropriate treatment he obtained pure cellulose, as might have been expected. This was evidently also expected by Field-Marshal Vaillant, who happened to be present when the *savant* deposited, at a meeting of the Agricultural Society, a piece of pure cellulose obtained from the wood of the old pump, since the Marshal asked Payen, jocosely, whether he had not some old wood from the ruins of Carthage to operate upon; and M. Robinet, improving upon the occasion, offered to send Payen a piece of the wood from Noah's Ark, to continue his researches.

Artificial ebony is the name given to a substance prepared on the large scale in the following manner: 60 parts of charcoal, obtained from sea-weeds, and previously treated with dilute sulphuric acid and dried, are ground to powder, and mixed with 10 parts of

liquid glue, 5 of gutta-percha, and 2½ of caoutchouc, care having been taken to mix the two latter substances with coal-tar oil, and thus to render them gelatinous; next, 10 parts of coal-tar, 5 of pulverized sulphur, 2 of pulverized alum, and 5 of powdered resin are added, and the mixture heated to 300° F. After having cooled, a substance is obtained which, in every respect, is said to equal genuine ebony wood, but is far less expensive, and takes a finer polish.

M. H. Pajot has made a series of experiments on the large scale at the blast-furnaces of Baudonnay, département de l'Orne, and found that the fact announced many years ago by Messrs. Lyon Playfair and Bunsen, of the presence of cyanide of potassium in blast-furnaces, is a reality, and that the salt is formed there in such large quantities that it might easily become a useful and plentiful by-product of ironworks.

A French technical paper especially devoted to the art of paper-manufacture, states that any alterations or falsification of writings in ordinary ink may be rendered impossible by passing the paper upon which it is intended to write through a solution of gallic acid in pure distilled water. After the paper thus prepared has become thoroughly dry, it may be used as ordinary paper for writing; but any attempt made to alter, falsify, or change anything written thereon, will be left perfectly visible, and may thus be readily detected.

On the evening of the 22nd of May last, at 9.45 P.M. local time, there was heard at Vannes, the capital town of the department of Morbihan, a heavy report, like that due to the firing of large ordnance, while the sky was at the same time illuminated by a bluish white light, accompanied by sparks somewhat like those of fireworks. The next day M. Limur learned that, at Cléguerec, a meteoric stone had fallen, which had been broken into pieces by the peasantry, and fragments of which, weighing 22 and 16 kilos., had been secured by some parties who, knowing the value scientific men attach to these extra-terrestrial visitors, will shortly send them to Paris for investigation.

Proceedings of the Chemical Society.

In continuance of our reports of this Society, we have to record that on June 3 the Society met to hear a lecture by the President (Dr. Williamson) "On the Atomic Theory." It is impossible for us to give a condensed report which will do justice to so important a subject.

The Chairman, Dr. Miller, proposed a vote of thanks to

Dr. Williamson, and said that it would be better to defer the discussion. He would, however, remark that those who opposed the atomic theory must explain how, according to the notion of the infinite divisibility of matter, they had combination in definite proportion at all. It seemed to him utterly impossible to explain combination in definite proportion by the theory of infinite divisibility.

On the 17th of June the Society met at the Royal Institution, Albemarle Street, on the occasion of the delivery, by the celebrated French chemist Dumas, of the Faraday Lecture.

The President, Dr. A. W. Williamson, F.R.S., first addressed the meeting in appropriate terms, introducing M. Dumas. He said that the Society was here assembled to inaugurate what would be inadequately described as a monument in honour of Faraday. The Faraday Lectureship had been founded by the Council of the Chemical Society in the hope that it would promote the advancement of human knowledge, and surely no higher tribute of respect could be paid to a great man than to do in his name what he would have loved best to see done. The greatest difficulty which is experienced, and the greatest defect which one observes, is this, that workers in one line of thought are frequently ignorant, or insufficiently cognizant of what others are doing, and the defect shows itself between those who are working in different countries more than between those who are working in the same country. Now, imagine that we could induce to come among us a man possessed of one of those master minds which forms a focus of light throughout science and amongst all those who are interested in science; suppose that he were to tell us the thoughts which are uppermost in his own mind, and—best of all—that he were to make us for a time think with him in the very words of his own language; imagine that such a highly-gifted man combined in his own person the genius of a discoverer, the breadth of intellect of a philosopher, and the lucid fluency of an orator. I am sure that you would agree with me, that his visit would inaugurate something which Faraday would truly have rejoiced to see. Imagine, I say, those things, accurately fix in your mind's eye the image of such a man—and Dumas is before you.

M. Dumas's lecture commenced with a brief *éloge* of his friend the late Professor Faraday. The lecturer then, with admirable eloquence, passed to the consideration, first, of what he termed "*la matière brute*," and of its forces; and secondly, of organic matter and the forces special to it. He traced the origin of some of the more important modern chemical doctrines, of the labours of the Greek philosophers, and identified the principle of the ancient classification into fire, air, earth, and water, with that of Lavoisier's chemical elements. He acknowledged his great admiration of the labours of Dalton and Prout, and in a most lucid manner pointed

out relations between the atomic weights of the now received elements which led him to infer the probability of many of them having a common basis.

The conclusion of this lecture was so eloquent, and at the same time so profoundly suggestive of new lines of thought, along which chemists have scarcely yet penetrated, that we cannot refrain from quoting it *in extenso*:—

"The chemist has never manufactured anything which, near or distant, was susceptible even of the appearance of life. Everything he has made in his laboratory belongs to 'brut' matter; as soon as he approaches life and organization he is disarmed.

"Is the intimate nature of matter known to us? No! Do we know the nature of the force which regulates the movement of the heavenly bodies, and that of atoms? No! Do we know the nature of the principle of life? No!

"Of what use then is science? What is the difference between the philosopher and the ignorant man?

"In such questions the ignorant would fain believe they know everything; the philosopher is aware that he knows nothing. The ignorant do not hesitate to deny everything; the philosopher has the right, the courage, to believe everything. He can point with his finger to the abyss which separates him from these great mysteries,—universal attraction, which controls 'brut' matter; life, which is the source of organization and of thought. He is conscious that knowledge of this kind is yet remote from him, that it advances far beyond him and above him.

"No! Life neither begins nor ends on the earth; and if we were not convinced that Faraday does not rest wholly under a cold stone, if we did not believe that his intelligence is present here among us and sympathizes with us, and that his pure spirit contemplates us, we should not have assembled on this spot, you to honour his memory, I to pay him once more a sincere tribute of affection, of admiration, and respect!"

6. ENGINEERING—CIVIL AND MECHANICAL.

The past quarter has certainly been rather prolific of engineering enterprises, and can boast of the completion of two most important projects, in addition to the development of a third which will probably, ere long, rival Sir Rowland Hill's penny postage in its universality and general public value.

Government and the Telegraphs.—By an Act passed in the last Session of Parliament power was given to confirm certain agreements which had been entered into between the Post-office autho-

rities and the various telegraph companies and railways throughout the country. An Act of the past Session empowers the Postmaster-General to pay to the various companies the sum of 5,715,047*l.* for the purchase of their undertakings; a further sum of 700,000*l.*, it is estimated, will be required for the purchase of telegraphs belonging to railway companies whose lines are doing public telegraph business; and 300,000*l.* has, in addition, been set down as the probable amount that will be required for extensions. The present proposals of the Post-office authorities are to serve with means of telegraphic communication some 3376 places instead of 1882 as at present. Altogether a sum of 6,750,000*l.* is expected to be required for the purpose, and the gross annual revenue is set down at 673,838*l.* The net profits to Government have been estimated at from 44,000*l.* to 77,000*l.* per annum, according as to whether the money can be raised at 4 or 3½ per cent.

Pacific Railroad.—The completion of the Pacific Railroad has given a line of communication 3300 miles long, between New York and San Francisco, connecting the Atlantic with the Pacific Ocean, and crossing a mountain range higher than any other line in existence. On the 28th April last 10 miles and 58 feet of railroad were completed between daylight and sundown, a feat hitherto unparalleled in railway construction, and as such one well deserving of record in these columns.

French Atlantic Cable.—The successful completion of the laying of the French Atlantic cable is another engineering achievement of which the present age may fairly boast. The manufacture of the core for this cable was commenced on September 14, 1868, at the gutta-percha works, and the cable was finished in the first week of last June, at the sheathing works at East Greenwich. The route along which this cable is laid is well to the southward of existing cables; the point of departure from the French coast is between Brest and Cape Ushant, and the landing-place on the American coast is the small French island of St. Pierre. From thence a shallow-water cable is laid down the coast to Duxbury Cove, near Boston, Massachusetts. The greatest depth of water is 2200 fathoms in the deep-sea section. The quantity of cable manufactured for these sections is 3564 nautical miles, or about one-third longer than either of the existing Atlantic cables. The Great Eastern, with the main portion of the cable on board, reached Brest on the 21st June last, the French shore-end having been previously laid. A splice having been successfully made, the Great Eastern steamed off on her trans-Atlantic voyage early on the morning of the 22nd June, accompanied by a small fleet of minor vessels carrying other portions of the cable. On 15th July the laying of the cable was completed to St. Pierre, without the occurrence of any serious hitch or delay of any kind; and on the 15th of August last

the French Atlantic Telegraph Company opened their line for traffic. Thus the longest line of submarine telegraph in existence has been brought to a successful completion within eleven months of the commencement of its manufacture.

The Channel Passage.—In our last Chronicles reference was made to the various schemes recently put forward for effecting the better passage of the Channel between England and France. Since then the subject has attained increased importance, from the fact that publicity has recently been given to the report of a commission appointed by the French Emperor to examine into the project of a submarine railway between England and France, the result of whose deliberations was a recommendation to the effect that "The exploratory and preparatory works should be executed under the inspection of commissioners appointed by the two Governments (of England and France), to whose approbation the company should submit yearly in advance the plans and estimates to be executed in the current year, and who should control the expenses usefully made." From a further section of the report, however, it appears that "Three members of the commission are of opinion that the proposed undertaking appears to be incapable of producing sufficient remuneration for the capital employed; that, thus looking at it from a purely economical point of view and setting aside considerations which the Government are more competent to decide on than the commission in the present case, at this present moment there are no grounds for recommending the acceptance of the propositions of the committee." From the evidence taken by the committee, it appears that the chalky mass found at Cape Blanc Nez is reproduced with the same characteristics on the other side the Channel, between Folkestone and Dover. The lower part of the chalk-bed consists of grey and marly chalk, having a mean thickness of 55 to 65 yards, which crops up at Cape Blanc Nez and near Folkestone. "In this situation its composition is uninterrupted and free from fissures, and possessing, on account of the marly beds which are intercalated with it, a degree of elasticity which the engineers expect would be maintained." On the whole the commission express their opinion that driving a submarine tunnel in the lower part of this chalk is an undertaking which presents reasonable chances of success; but in the absence of further information, they decline to mention any sum as the probable amount which would be required for its completion.

A report on the best means of facilitating communication between England and France has since been drawn up by Captain Tyler, of the Board of Trade. This officer has an evident leaning towards the lesser expenses contemplated in Mr. Fowler's large ferry-boat scheme, rather than to the projects of Mr. Hawkshaw, M. de Gamond, and the late Mr. Chalmers, for effecting absolute

and direct communication with the Continent by means of a subaqueous tunnel. The substance of Captain Tyler's recommendations may be summed up in the following extract from his report:—"Either by the construction of new harbours at Dover and Andresselles, at a cost (estimated by Mr. Fowler) of 2,000,000*l.* inclusive of steamers, or by certain improvements at Dover and Boulogne, at a cost of 600,000*l.* exclusiv of new and improved steamers, the immediate object should be to provide an improved fixed service, irrespective of wind and tide, between London and Paris in eight hours." Thus this important matter rests for the present, but it remains to be seen what further action will be taken by the two Governments towards the solution of a project, the commercial and international advantages of which may be estimated as being scarcely second to those of the Suez Canal. The appointment of an International Commission for the purpose of discussing the several projects for effecting improved communication with the Continent, as recommended by Captain Tyler, will, however, probably prove the best means of bringing this important question to a satisfactory issue.

Utilization of Small Coal.—Although we are no believers in the probability of the speedy exhaustion of our coal-fields, we are nevertheless, upon other grounds, strongly in favour of all measures calculated to economize our present supplies, and to check the extravagance which now characterizes our use of that fuel. In addition to improved arrangements of furnaces whereby more perfect combustion is ensured in the coal ordinarily used, namely, that which is taken from the pits in blocks of some size, attention has recently been given, in more directions than one, to bringing into use the small coal, or slack, which had previously been counted as so much waste. Some reference to this subject will be found in another part of the present volume, in an article on "Coal Washing." Besides its conversion into coke, which is now very much the practice at all collieries, small coal is, to a certain extent, employed in the manufacture of Patent Fuel; and at the present time experiments are being carried out in this country by Mr. F. C. Danvers, for the Indian Government, with a view to ascertaining whether that manufacture could be successfully introduced into India, so as to utilize further than is at present done the coal products of that country. Methods of burning small coal, without subjecting it to any previous preparation, if equally applicable, must, however, prove the more economical process, and several furnaces have from time to time been devised for this purpose. It is almost needless here to state that the most perfect furnace would be that in which proper means exist for the regulation of the introduction of air in the best direction into the combustion chamber, so as to effect the most perfect combustion of the fuel,

whilst the fire-grate must be so arranged as to avoid the disadvantages usually attendant on the use of slack, such as the loss of a quantity of fuel by falling, unconsumed, through the bars, or the obstruction of a proper draught by cakeing into blocks over them. Fire-doors of this description are made by Messrs. Newton and Newton, at Liverpool, and appear to possess great advantages, not only in enabling slack to be burned where large coal would otherwise be necessary, but by a proper regulation of the air admitted to furnaces to which they are fitted, more perfect combustion is ensured, resulting, consequently, in the almost total prevention of smoke.

We cannot close this subject without a brief notice of Mr. Thomas Russell Crampton's process of burning fuel in the form of a powder. Many previous experiments have been made both in England and America to effect a similar object, but they have failed to achieve that amount of success which Mr. Crampton appears to have arrived at. Mr. Crampton's process, described in few words, consists of an arrangement by which a portion of finely-powdered coal is blown into a furnace, where at first a small fire has been lighted. This immediately bursts into flame, and by properly adjusting the proportions of air and coal-powder, a flame is then regularly kept up, giving out an intense heat, and leaving little or no residue in the shape of clinkers or ash. Want of space prevents further allusion to this subject now, but we shall return to it again upon some future occasion.

Meetings of Scientific Societies.

Institution of Civil Engineers.—The President's annual conversazione took place on Tuesday, the 25th May last, at which there were present an unprecedented number of visitors and members. The meetings of the Institution have now been suspended until the autumn.

Institution of Mechanical Engineers.—The annual meeting of this Society was held at Newcastle on 3rd August last, and following days, under the presidency of Sir William Armstrong, when the following papers were read:—"On the Hydraulic Swing Bridge over the Ouse," by the President; "Mechanical Ventilation of Mines," by Mr. William Cochrane, of Elswick; "Mechanical Firing of Steam Boilers," by Mr. John Daglish, of Seaham; "Hydraulic Machinery for Warehousing Grain," by Mr. Percy G. B. Westmacot, of Elswick; and on "The Navigation of Canals," by Mr. Max Eyth, of Leeds. The President, in his address, which was given before a crowded audience on the evening of the first day's meeting, after alluding to the present year being the cente-

nary of the steam-engine of Watt, briefly referred to the early history of its invention and progress. He then entered upon the subject of coal-mining; the construction and use of large ordnance; armour-plating; the future of the steam-navy, and gun-carriages.

Civil and Mechanical Engineers' Society.—Two meetings of this Society have been held since our last Chronicles were written, which took place on the 2nd and 9th June respectively. At the former meeting the Society was occupied in listening to, and subsequently discussing an able paper by Mr. Arthur C. Pain, C.E., "On the principal Building Stones used in the Metropolis." And on the latter occasion a very interesting paper was read by Mr. Frederick H. Roberts, C.E., on "Steam and other Power Hammers."

Literature.

'*A Manual of Machinery and Millwork*,'* by William John Macquorn Rankine, C.E.; LL.D. Trin. Coll., Dublin; F.R.S.S. London and Edinburgh; F.R.S.A., &c. &c. This volume forms the last of the series of practical manuals to which it belongs. Those which have preceded it are probably well known to many of our readers. The professional position and world-wide reputation of the author are sufficient to stamp all his works with an authority which place them almost above the range of criticism. The work now under review is divided into three parts, treating respectively of the "Geometry of Machinery," the "Dynamics of Machinery," and the "Materials, Strength, and Construction of Machinery," each part being subdivided and the subject matter treated under various and well-arranged headings. Want of space prevents any more detailed account of the present work, but we may, in conclusion, state that, although dealing with the principles of machinery and millwork, it is of a character entirely distinct from that of Dr. Fairbairn's excellent work on Mills and Millwork, the latter treating more of the practical application of principles, whilst Professor Rankine's work deals with the principles themselves.

* London: Charles Griffin & Co.

7. GEOLOGY AND PALÆONTOLOGY.

(Including the Proceedings of the Geological Society and Notices of Recent Geological Works.)

Mr. Robert Hunt has contributed a highly suggestive and interesting paper to the 'Bath and West of England Agricultural Journal'* on "The Economic Geology of Devonshire and Cornwall in 1868." In it the author points out that, although other districts may exhibit greater varieties in their geological formations, yet there are few in which the *rock-conditions* are so peculiarly adapted to the production of that high fertility which distinguishes Devonshire, or the varied and valuable metalliferous deposits of Cornwall. Mr. Hunt gives a brief sketch of the various deposits which characterize the two counties, and proceeds to show the intimate connection which exists between the rocks beneath and the fertility of the soil above. He thinks that the agriculturist might study with advantage the geologically-coloured map of a district, and learn from it which are the more and which the less productive tracts; but he points out that elevation above the sea, exposure to prevailing winds, drainage-lines, &c., must also be taken into account.

The author contrasts the soils lying on the Lias, the New Red Sandstone, the slaty series (Devonian and Carboniferous), and especially to those derived from the decomposition of cruptive rocks and granites, as yielding good crops of ordinary farm-produce, and favourable to the growth of grass and potatoes. He mentions the beneficial results witnessed by spreading "China-stone," a semi-decomposed talcose granite, in small pieces over a field of wheat, and suggests that we may yet add many new fertilizers to the list of artificial manures offered to the farmer. He affirms that the relations of geology to agriculture are not yet in a satisfactory condition; but that, in addition to the maps now issued, showing the boundaries of the rock-formations, we need maps of the surface, showing the variation and distribution of soils. He also adds the welcome intelligence that Government has organized measures for accomplishing this end.

Turning from agriculture, Mr. Hunt proceeds to describe the mineral resources of the district. Commencing with fuel, he states that 1368 tons of the Bovey Tracey lignite are annually used at the Bovey Potteries, besides the district consumption. These beds belong to the Miocene age, and are only a little older (geologically) than our peat-mosses and peat-bogs, which can also be cut and utilized as fuel. None of the four million tons of coal, drawn

* Vol. xvi.

annually from our Coal-measures proper, are obtained from this area.

From coal we pass to tin, copper, lead, iron, zinc-ore, nickel, wolfram, manganese, arsenic, &c., and then to building-stones, ornamental marbles, roofing-slates, flagstones, lime, whetstones, clays for pottery, &c., yielding a total value of 1,876,739*l.* for the two western counties.

The Depths of the Sea.—In a lecture lately delivered before the Royal Dublin Society, by Prof. Wyville Thomson, the lecturer gives us the results of dredging operations carried on by Dr. Carpenter and himself last year in deep water between the Faroe Islands and the Hebrides.

Two areas were explored—a "cold area," where the bottom was of stones and coarse sand, and on which the thermometer registered a minimum temperature of 32° F., and where the fauna consisted of a meagre sprinkling of boreal and arctic forms—and a "warm area," the "Gulf-stream area" (530 fathoms deep), with a minimum temperature of 47°·5 F., where the floor was covered with fine grey slimy mud, technically called "ooze," but which Prof. Wyville Thomson considers should be called "chalk-mud." This area, which formerly yielded only the shells of a Rhizopod (*Globigerina*), now proved to be also rich in siliceous sponges, about forty of which were obtained on one occasion, a little south of the Faroes. Most of these sponges had long and venerable beards of flint-spicules, as fine as the finest floss-silk, spreading out into the chalk-mud in all directions. These beards brought up, entangled in them, small clams, starfishes, and minute crustaceans; and among the mud were scattered the shells of the beautiful and well-known Pteropods of the Gulf-stream.

There can be no doubt, adds Prof. Wyville Thomson, that Chalk is now being formed in the depths of the Atlantic; and not only Chalk, but THE CHALK—the Chalk of the Cretaceous Period. That, in fact, the physical and biological conditions of the greater part of the ocean have remained unaffected by the later geological changes embraced within the Tertiary and Quaternary Periods, which represent only minor oscillations, the deposits formed during those periods being all laid down in comparatively shallow water, as shown by the nature and richness of their faunæ.

It is gratifying to find that whilst the results arrived at from the more perfect appliances for modern deep-sea dredging have so materially modified the late Professor Edward Forbes's conclusions as to the depths in the ocean at which life could be sustained—yet they have also tended to confirm the doctrine which he long ago enunciated, that the persistence of the same fauna over an extended geological area did not prove it to be synchronous, but rather the reverse.

In the latter part of 1867, Mr. W. Hellier Baily (Palæontologist to H. M. Geological Survey of Ireland) published Part I. of 'Figures and Descriptions of Characteristic British Fossils' (Van Voorst). We are glad to notice the publication of Part II. with Plates 11–20 (Lower and Upper Silurian). This publication is not intended in any way to interfere with 'Morris's Catalogue of British Fossils' (the third edition of which is very much needed by all palæontologists). Mr. Baily's aim has rather been to assist geological students, and others who, from their limited knowledge of palæontology, require to have figures of the various fossils placed before them, as well as their names and references, in order to enable them to identify their specimens. Those who have the good fortune to possess a scientific reference library, or who can use that of some public institution, can hardly understand the assistance which such a work as this affords to others who, from their isolated position, are denied these advantages.

We hope Mr. Baily may soon be able to complete the publication of his 'Figures and Descriptions of British Fossils,' that we may enjoy the use of it, *as a whole,* before many years have passed away.

The 'Geological Magazine' contains various articles of interest. The following chiefly deserve notice :—

1. A full report (with illustrations) of Mr. W. Carruthers's lecture, at the Royal Institution, on "The Cryptogamic Forests of the Coal Period." Mr. Carruthers points out that the Flora of the Coal Period all belonged to the Vascular Cryptogams, and represent—(*a*) the Ferns; (*b*) the Horse-tails, *Equisetaceæ*; (*c*) the Club-mosses (*Lycopodiaceæ*). After describing the modern representatives of these three types, the author proceeds to point out that in the Coal Period, (*a*) Ferns were most abundant, mostly, however, humble herbaceous forms, very few attaining the size of modern tree-ferns; their leaf-forms being nearly all comparable with living species. (*b*) The *Equisetaceæ* were well represented in the Coal Period, but instead of being dwarf marsh-plants, they attained often a very large size. He described the stems, the various forms of foliage and fructification belonging to this group, and pointed out their affinity to the modern Horse-tail (*Equisetum*). (*c*) He next considered the fruit and stem of *Lepidodendron*, contrasting those giant trees with the modern Club-mosses, and showed that in that point most relied on by Botanists—the spores—there was a close agreement. He spoke of *Sigillaria*, another arborescent form, also a member of the same family as *Lepidodendron*. These are the plants to which we are indebted for our stores of mineral fuel. They grew in extensive level plains, their fleshy roots penetrating the soft mud which formed the surface-soil, or the spongy layer of vegetable matter which covered it. The

moist atmosphere (not at all likely to have been charged with more carbonic acid gas than that of our own day) would encourage the growth of cellular parasites and epiphytes, &c., probably representing races much higher in organization than the cryptogamic trees on which they flourished. The examination of the Flora of the Coal Period reveals to us an assemblage of plants agreeing in all essentials with some of the humble members of our present Flora, but attaining at so early a period in the history of the world, a development, not only in size, but in organization, greatly in advance of their modern allies.

2. The fourth part of Mr. Davidson's "Notes on Continental Geology and Palæontology, including a Sketch of the Geology of Nice."

3. "Notes and Figures of the Teeth of *Ctenodus* from the Coal-measures," by Mr. T. P. Barkas.

4. "On the Genus *Æchmodus,* from the Lias of Lyme Regis," by Professor Morris, F.G.S. (with a plate). In this paper Professor Morris considers the genera *Dapedius, Æchmodus,* &c., and discusses the characters upon which they are founded. These Liassic fishes, with their tesselated surface of highly enamelled black rhomboidal scales, form most striking objects among the fossils of this singularly rich deposit, and, from the perfect state in which they are frequently found, are sure to attract special attention.

5. Dr. Linnarsson's paper "On Fossils from the Eophyton Sandstone of Sweden" is reproduced, together with the original plates representing these singular bodies, believed by Dr. Torell and some naturalists of eminence to be plant-remains, but of the certainty of such determination much doubt still exists; they have by others been considered worm-tracks and Trilobite-markings, &c. Whatever their origin, they seem to be due to organic bodies, which is, after all, the main point of interest.

6. Professor Owen contributes a note on the occurrence of the Elk with the Reindeer, &c., at Walthamstow, in Essex.

7. Sir Philip Egerton supplies a list of the Typical Fishes in his collection at Oulton Park, which he states are open to inspection by all who take an interest in palæontology.

8. Mr. H. C. Sorby contributes a note "On the Excavation of Valleys in Derbyshire."

9. Mr. H. B. Medlicott "On Faults in Strata;" and

10. Mr. G. H. Kinahan "On the Growth of Soil, Formation of Ravines," &c., &c.

Proceedings of the Geological Society of London.

As there are twenty-nine papers published in the August number of the Quarterly Journal of this Society, it is impossible to do more than to briefly notice one or two of the most important ones:

1. Professor Henri Coquand compares the Cretaceous strata of England and the North of France with those of the West and South of France and the North of Africa. In this paper the author points out that although a comparison may be made between the Cretaceous beds of Paris and in the North of France with those of England, without any great discrepancies being discovered, immediately one examines the Cretaceous beds of Provence, one finds—1st, thick beds with *Radiolites*; 2nd, 300 mètres of Sandstones (Grès d'Uchaux); 3rd, 150 mètres of Limestone with *Hippurites*, which are wanting both in the Parisian and the English Chalk series. He pleads, and we think with justice, that, as each district possesses its peculiar and local formation, it is there that one should seek for the type, and that if these beds had occurred in England we should certainly have made an horizon for them, and given them a place and a name; why then should they not take a place in the series, and be recognized by foreign geologists?

2. Mr. W. Carruthers, "On the Structure and Affinities of *Sigillaria* and allied Genera," indicated the characters of the medullary rays of dicotyledonous stems, and stated, that they have a vascular horizontal system connected with the axial organs, in which respect they agree with acrogens. The woody columns of *Stigmaria* and *Sigillaria* are destitute of medullary rays, the structures previously described as such being the vascular bundles running to the rootlets and leaves. Hence the author concluded that *Sigillaria* is a true cryptogam.

3. Professor T. H. Huxley describes a new Labyrinthodont Amphibian reptile from the Black-bed coal of Bradford, Yorkshire, which the author considers was nearly allied to the genus *Pholidogaster*, and for which he proposed the name of *Pholiderpeton*. It exhibits portions of both jaws, with close-set, nearly equal teeth, nearly circular in section, and slightly recurved at the apex. The ventral armour consists of oval plates, traversed obliquely by a convex ridge dividing them into two unequal parts; these plates overlapped each other so as to expose only the surfaces of their oblique ridges.

4. "On the Upper Jaw of *Megalosaurus*," by the same author. The information concerning the skull of this reptile was very defective, only a portion of the lower jaw being known heretofore. The beautiful upper jaw, with the teeth, now figured and described, from the Stonesfield Slate, adds greatly to our knowledge of this very interesting and gigantic Dinosaurian.

It shows the left side of the jaw, measuring 18 inches in length and 4½ inches in depth anteriorly. One tooth, exposed in its whole length by the breaking away of the bone, measures 6·4 inches, of which the crown forms only 2·6 inches. An animal with almost identical teeth, the *Teratosaurus Suevicus*, of Von Meÿer, occurs in the Lower Keuper of Stuttgardt, thus giving to this type of Dinosaurian a range from the Trias to the Wealden.

Among the Geological papers, the most important is that by the Rev. J. M. Joass "On the Sutherland Gold-fields," and by Mr. J. J. Murphy "On the Nature and Cause of Glacial Climate."

We regret that want of space precludes our noticing the numerous other papers contained in this number.

8. METEOROLOGY.

Meteorology in France.—Our last Chronicle was barely in type, when the statements contained in it relating to the organization of meteorological operations in France were shown to be incorrect. We learn now that the Government has communicated to the Société Météorologique its intention of instituting a complete system of meteorological observations, in a connection more or less intimate with the Society. A commission has been appointed, with Prof. Charles Sainte-Claire Deville as its President, to superintend the work. A central observatory has been established at Montsouris, near Paris, with which it is hoped that other institutions will soon be affiliated, and the issue of a daily bulletin of the observations made at Montsouris has been set on foot since the beginning of July. It may therefore be expected that ere long a complete system of meteorological observations will be in operation, and we cannot but express our satisfaction at the evidence which these facts afford that the authorities in Paris fully recognize and identify themselves with the work so long and so well done by the Meteorological Society of France. As regards the issue of the Bulletin International, no modification of the service at the Observatoire Impérial will be made in consequence of the change.

The Aurora.—The remarkable auroras noticed on April 15 and on May 13, of which Mr. Barber was so kind as to furnish a notice for our last number, have attracted very considerable attention over the whole of Europe, and have formed the theme of several interesting communications to scientific societies. Among the most important of these have been the notices submitted by MM. Silberman and C. Sainte-Claire Deville to the French Academy, and contained in the Comptes Rendus. These gentlemen, the former especially, have

paid particular attention to auroral phenomena of late years, and the views entertained by them receive abundant confirmation from the facts observed on the dates in question. The connection between the aurora and magnetic storms is well known and recognized, but the relation between its appearance and the phenomena of our weather is not as yet nearly so universally admitted. The opponents of the idea of the existence of any relation, naturally and very justly urge the frequency of auroras in high latitudes, without any concomitant disturbance of atmospherical equilibrium. We must, however, remember that magnetic intensity is in general much greater in high latitudes than in our own, so that in these countries it is only at times of disturbance of the magnetic conditions of the atmosphere that we are to look for an exhibition of auroral appearances. The fact that auroras do occur nearly simulta cously with periods of stormy weather is too well established to be doubted; the point to be determined is whether there is or is not a connection between the two phenomena. Some connection is distinctly assumed as a fact by the authors of the papers we are now discussing. They show that the aurora manifests itself on the appearance of a centre of barometrical depression (a "bourrasque"), and that it belongs to the earlier period of the disturbance, when pressure is decreasing rapidly and temperature increasing,—in fact, to the period which is usually characterized by the manifestation of electrical phenomena such as thunderstorms. M. Silberman attributes the aurora to the gradual discharge towards the higher regions of the atmosphere, of the electricity contained in a thundercloud. This discharge only takes place when streaks of cirri emanate from the upper surface of the cloud, so that in fact it is induced by the congelation of aqueous vapour into the minute ice prisms of which the cirrus is known to be composed. The chief points in support of his theory, brought forward by M. Silberman, are the fact that cirri are almost invariably noticed as being present in the space above the dark segment during the exhibition of an auroral discharge; it is often remarked that the phenomenon entirely disappeared when the sky became completely overcast with a stratum of cloud; that during an auroral period, in the daytime, when their luminosity cannot be observed, it is frequently noticed that cirri occupy the position of the rays of the aurora;* and that frequently during an aurora a fall of small

* Very recently a remarkable confirmation of M. Silberman's statements has been witnessed by the writer of this Chronicle. On August 25 he was travelling from Thurso to Wick, and at 5 P.M., while the sun was shining brightly, he observed a dark bank of clouds along the northern horizon, exactly resembling the dark segment of an aurora. From this cloud long rays of cirrus directed towards the zenith emanated. Although at this period of the evening no auroral light was visible, it was remarked by some persons who observed the phenomenon that this was the commencement of an aurora. During the night the sky, which had been very clear for some days previously, became entirely overcast; but before this

crystals of ice, as distinguished from hail, has been observed. M. Silberman has himself noticed that at night thunderclouds, when there is no moon, give off occasional faint coruscations from their upper surfaces, and that when this latter appearance becomes of greater permanency, the ordinary electric discharge, producing a thunderstorm, is entirely suppressed.

This idea of a relation between the aurora and the cirrus-cloud goes to establish a relation between the aurora proper and the appearance of luminous clouds, which are occasionally noticed. It is also interesting in this connection to refer to the remarkable observations made many years ago by Sir E. Sabine, at Loch Scavaig, in Skye, where he remained for a short time at anchor in a yacht. One of the mountains close to the loch was constantly covered with a cap of cloud, and at night discharges of a true auroral character were seen to emanate from this cloud. It was distinctly proved that these did not belong to an aurora at a distance, of which the lower portion was obscured by the mountain. Another fact, in some way corroborative of M. Silberman's views, is that some of our most experienced arctic observers state that the aurora is never noticed unless there be open water in the vicinity of the observer, and consequently a considerable degree of humidity in the air.

The auroras to which the papers in question especially refer are very remarkable, owing to their very great extension; that of April 15 being noticed from the Azores to Central Germany, and that of May 13 from the British Isles to Russia, where it was well observed. In a communication to the Academy of Sciences of St. Petersburg, Prof. Wild gives an extract of a letter from Von Struve, of the observatory at Pulkowa, who remarked that the phenomenon, though remarkably brilliant, was chiefly noticed in the east, and that the dark segment was entirely absent. This latter particular was especially adverted to by M. Silberman in Paris, who remarked that its place was taken by a number of small clouds in various parts of the sky, forming separate auroral foci.

The April number of the 'Proceedings of the British Meteorological Society' is mainly composed of two papers on the influence of the moon on rainfall, which lead to diametrically opposite conclusions. Mr. Dines states, as a result of the discussion of forty years' observations, that no influence is traceable; while Mr. Glaisher has submitted fifty-four years' observations to calculation, and has arrived at the conclusion that the amount of rain which falls increases to a maximum about the tenth day of the moon's age,

occurred, the light of a faint aurora was perceived. Next day was very cloudy, and in places in Scotland rain fell. On the 27th the sky cleared again, another aurora appeared at nightfall; and on the 28th a very sudden change of weather occurred, the temperature falling very rapidly, while a strong N.W. wind set in, attaining in some places the force of a gale.

while the average amount of rain "per fall" has its maximum at the end of the lunation. The differences are, however, not great, and it seems scarcely necessary to have printed twenty-three pages of tables on such a subject.

Underground Temperatures.—The April number of the 'Journal of the Scottish Meteorological Society' contains a paper by Mr. Buchan, being the first notice of the observations of underground temperature carried on at certain stations in Scotland. The Marquis of Tweeddale, President of the Society, had most liberally placed 50*l.* at the disposal of the Council, to be expended in investigating the question. The thermometers were placed at depths of 3, 12, and 22 inches, under grass, at all the stations but one, where they were placed under the bare soil, so as to reproduce the conditions of a freshly-sown field. As might be expected, the last-named station exhibited a much higher temperature at the depth of 3 inches than those where the soil was covered by vegetation. The results are of some interest. In drained ground the surface temperature of the soil rose above the temperature of the air to the extent of 2°·4 on the mean, while in badly-drained ground it fell slightly below the air temperature. Light soils also exhibited an excess of temperature as compared with that of the air, while heavy soils were characterized by a defect. These results are naturally to be expected, as a dry light soil is a much worse conductor of heat than wet heavy ground.

There is one observation which merits special notice; on a cold day, with a north-east wind, cloudy but dry, it was found that the thermometer at the depth of 3 inches rose above that in the air 3°·7 at Sandwick Manse, where it was under grass, and 5° at Thirlestane Castle, where the soil was uncovered, while the temperatures at 12 and 22 inches respectively scarcely varied during the day. This shows us that during the cold east winds of spring seed in the ground may be enjoying a temperature much higher than our sensations of air temperature would lead us to expect, and it also accounts for the greater severity of the east winds on the east coast than on the west, which they can only reach after having travelled over a large extent of heated soil. Mr. Buchan is disposed to attribute the elevation of temperature to the radiation of heat from the clouds.

Meteorology of Iceland.—The same number contains a notice of the meteorology of Iceland, based on the observations of Mr. O. Thorlacius, carried on for twenty-three years. The results are interesting, when we compare them with the corresponding figures for Scotch stations noticed in our last number; however, they exhibit some points of difference, the mean pressure showing only 2 maxima and 2 minima instead of 3. The chief feature of the barometrical tables is a great depression noticed in the month of January, and

amounting to 0·3 inch below the mean of the year, and to 0·5 below the extreme monthly mean of that of May. At Glasgow the difference between the means of January and May amounts to only 0·17 inch. Pressure in Iceland is most unsteady in February, and most steady in July.

We may here notice the discussion of the scientific results of the German North Polar Expedition of last year, which has been published by the Meteorological Office of Hamburg (the Norddeutsche See-warte). It appears from the meteorological observations that the large and unexpected accumulations of ice met with by the 'Germania,' which had the effect of preventing her reaching the coast of Greenland, were in great measure connected with the abnormally low mean temperature prevailing in high latitudes during last summer. The mean daily temperature observed on board the ship was 3°·5 F. lower than that which was due to her geographical position. These facts afford a strong corroboration of the views long maintained by Prof. Dove, *viz.* that there is a constant compensation between the non-periodic variations in meteorological means. A warm season in any region is an indication that in an adjacent district the weather is unnaturally cold. Our readers will not forget the great warmth of last summer (1868), and yet during the whole of the period the temperature north of the parallel of 70° was unusually low. As regards the winds observed, the general direction of their change was from N.E. through N. to N.W., being thus in contravention of the law of gyration. Storms were far more frequent from the N. and N.E. than from any other quarter. The extraordinary prevalence of calms and of fog and mist is also very noticeable.

Deep-Sea Temperatures.—The paper, which is a report of a lecture delivered by Herr von Freeden, at Hamburg, contains a long discussion on the currents, &c., noticed during the voyage, and also some notes as to deep-sea temperatures and their indications as to submarine currents. As to the observations themselves, none go to a depth greater than 170 fathoms, where a temperature of 33° was recorded. The position assumed by the lecturer in interpreting the observations is rather at variance with the ideas generally entertained. Herr von Freeden states that by recent observations in the open sea it has been established beyond a doubt that salt water possesses a maximum density at 39°·5 F. In No. 22 of this Chronicle we entered on this question at some length, but new light has since been thrown on it.

On the one hand, Prof. Mühry of Göttingen has published a notice in the Journal of the Austrian Meteorological Society, in which he states that having tried the experiment, he finds that salt and fresh water have the same point of maximum density, and that, accordingly, all deep soundings ought to show this temperature.

On the other hand, investigations carried on here in London have led to the idea that the deep-sea temperatures hitherto recorded, many of which were far below 39°, have been as a general rule much too high. No account had been taken of the alteration in shape of the thermometer-bulb produced by the compression to which it was subjected in deep soundings.

On this subject Prof. W. A. Miller submitted to the Royal Society, in June, a notice of a thermometer calculated to register correct temperatures, independently of pressure. The principle on which this new thermometer is constructed is one which had been tried by Admiral FitzRoy some years ago, and it is this. The entire thermometer is enclosed in an outer glass coating, the interval between the two surfaces being nearly completely filled with a liquid. Compression of such an instrument only causes the liquid to fill a larger proportion of the intermediate space, and the bulb of the internal thermometer is entirely unaffected.

In Admiral FitzRoy's thermometers this liquid was mercury; in Prof. Miller's it is spirit. We learn from the paper submitted to the Society that the new instruments have been subjected to very severe hydraulic pressure in a special apparatus, constructed by Mr. Casella, their maker, and have performed very well.

The 'Porcupine' has been furnished with these instruments, and we may hope that the savans who take part in the present dredging expedition in the Atlantic will bring home some thoroughly trustworthy information as to the physical condition of the sea beneath the surface.

Report of the Meteorological Office.—The Report of the Meteorological Committee for the year 1868 has just appeared. The value of the information contained in its seventy-two pages must not be judged of by its price, which is only *5d.* It consists of two parts, with copious appendices. From the summary of Part I. we learn that the department of marine meteorology has made steady progress during the year in the discussion of observations relating to the equatorial portion of the Atlantic Ocean, and in the collection of new observations. We have already noticed the charts of sea-surface temperature which have appeared, and we learn that in addition to these charts materials have been supplied to the Admiralty for the compilation of pilot charts.

The system of telegraphic weather intelligence, established by the Committee, is in active operation, and storm warnings are sent to 101 stations on our own shores and to the adjacent coasts of the Continent. The work of the office in this department is carried on in cordial co-operation with that conducted in foreign countries.

As regards the land meteorology of the British Islands the seven observatories are in active work, and the most earnest attention of the Committee has been directed to the utilization of the

records furnished by their self-recording instruments in the study of weather, and their publication in a graphical form, which shall be acceptable to the scientific public. It is satisfactory to learn that some progress is being made in placing weather study on a secure scientific basis.

Part II. of the Report is an account of the means adopted by the Meteorological Committee, in conjunction with the Kew Committee, to ensure accuracy in the numerical results obtained from the records of the observatories. According to the plan adopted, each observatory supplies to Kew the photograms furnished by the instruments, together with hourly numerical values of the readings obtained by measurement. These are examined at Kew; and when certified as correct, are sent to the central office in London for discussion, &c.

The experience of the first few months showed that a more searching examination at Kew than had at first been contemplated was necessary, in order to prevent errors creeping into so large a mass of figures. The mode in which this examination is carried out is given at full length.

On the fly-leaf of the Report we see notices of other publications; an account of which, together with other meteorological literature, must be reserved for our next number.

9. MINERALOGY.

NOTHING tends more to impede the progress of a science than the hasty enunciation of laws based upon too narrow an induction. As our means of observation become extended, it is easy to detect the fallacy of many of our premature generalizations; but it is extremely difficult to eradicate the influence which they may have exerted on the formation of our scientific ideas. Our attention has recently been directed by Dr. Laspeyres to the crudeness of many of those general propositions which, for several years past, have been accepted, with more or less reservation, as natural laws regulating the association of those minerals which enter into the composition of rocks. His remarks will be found in an excellent paper "On the Association of Magnetic and Titaniferous Iron-ores in Eruptive Rocks, and on the so-called Laws of Petrography."* It is commonly laid down, as a general proposition, that the two minerals here coupled together never occur associated as components of a rock—that, indeed, the presence of the one inva-

* 'Ueber das Zusammenvorkommen von Magneteisen und Titaneisen in Eruptivgesteinen, und über die sogenannten petrographischen Gesetze.' Leonhard und Bronn's 'Jahrbuch für Mineralogie,' u.s.w., 1869, p. 513.

riably betokens the absence of the other. Our author has, however, proved the co-existence of these species in the disintegrated product of certain volcanic rocks of the Palatinate, and also in an undecomposed rock, formerly termed gabbro, but which he now proposes to distinguish under the name of *Palatinite.* He is then led to a discussion of the ordinary laws of association among rock-forming minerals; and although he does not say very much that is original on this subject, it is nevertheless useful to review such a collection of facts as those which he has here brought together for the purpose of disproving most of the commonly-accepted conclusions. Thus he exposes the fallacy of the famous "law of the felspars"—a law which, as most geologists know, teaches that the alkali-bearing felspars — orthoclase, oligoclase, and albite — are never associated with the lime-felspars—labradorite and anorthite. One argument against this law might be found in the recent views of Tschermak on the constitution of the felspar-group, by which the so-called species, oligoclase and labradorite, are regarded as nothing more than isomorphous mixtures of the two extreme types—anorthite and albite. Moreover, as a matter of fact, Laspeyres has himself pointed out the existence of a lime-and-soda felspar, closely related to the labradorite type, in certain basaltic lavas of the Lake of Laach, where orthoclase had previously been found. In like manner, sanidine—a variety of orthoclase—occurs with anorthite in the andesite of Nagy-Bánya.

This example must suffice to show the kind of evidence with which our author sweeps away many a long-cherished notion; but it may please those who cling tenaciously to the old articles of faith to know that, in spite of the progress of science, a few of the petrographical laws still hold their ground; such, for instance, as the absence of white potash-mica from the younger eruptive rocks.

So much interest naturally attaches to anything bearing on the history of those strange visitants from extra-terrestrial regions, which occasionally reach our earth in the form of *meteorites,* that no apology is needed for calling attention to an excellent *résumé* of our knowledge on this subject, lately published by M. Stanislas-Meunier.* Most of our readers know that meteorites are divisible into two great groups—meteoric *stones* and meteoric *irons.* The members of the former class are composed of a stony base, consisting of a complex mixture of various magnesian silicates, only partially attacked by acids; those silicates which have the composition of olivine being decomposed, whilst others, resembling hornblende and augite, are left intact. Throughout this base of siliceous minerals, numerous grains are usually disseminated in greater or less number, some of which are metallic, and consist,

* "Recherches sur la composition et la Structure des Météorites:" 'Annales de Chimie et de Physique,' série iv., tome xvii. p. 5.

for the most part, of nickeliferous iron, chromite, and troilite. The author gives his analyses of three meteorites, one of which fell at Murcia, in Spain, on 24th Dec. 1858, and was exhibited in the Paris Exhibition; the second fell at Tadjera, in the district of Sétif, Algiers, on the 9th June, 1867, and is remarkable for the absence of that crust, or varnish, which usually invests such stones; whilst the third is a meteorite that fell on the 7th Sept. 1868, at Sauguis-Saint-Etienne, in the département of the Basses-Pyrénées. To economize space, we place the analyses side by side, and give only the mineralogical—not the chemical—composition.

	Murcia.	Sétif.	Basses-Pyrénées.
Silicates attacked by acids (olivine)	38·69	54·64	66·91
Ditto not attacked (augite)	24·64	28·80	23·57
Nickeliferous iron	14·99	8·32	8·05
Chromite	0·92	0·20	traces.
Troilite	20·52	8·04	3·04
	99·76	100·00	101·57

In the class of metallic meteorites the general mass is not homogeneous, but consists of a number of alloys of iron and nickel, each having a definite composition. Of these the most important are tænite, kamacite, plessite, and octibbehite. With these alloys are associated certain carbides of iron, chiefly chalypite and campbellite, a sulphide of iron called troilite, a phosphide of iron and nickel termed schreibersite, graphite or free carbon, and chrome iron-ore. Certain stony grains are also occasionally present, and frequently the surfaces are coated with a crust of oxidized matter. Add to this the occluded gases sometimes met with—such as the hydrogen found by Graham, and the nitrogen by Boussingault—and we have what in the present state of our knowledge is a complete catalogue of the constituents of meteoric irons.

At about 6 o'clock in the evening of the 5th May, 1869, a meteoric stone fell at Krähenberg, in the Bavarian Palatinate.* It presented the form of a flattened spheroid, and weighed 31½ lbs.; its surface was covered with a black rind, and exhibited numerous furrows. An account of this aërolite was read at the recent meeting of the British Association.

According to Dr. Sohncke, we can only hope to obtain an insight into the nature of those recondite forces that produce crystalline form, by determining with quantitative accuracy the relative degrees of resistance which a crystal opposes in different directions to the action of external mechanical forces. With this view the learned Doctor has instituted a very elaborate series of experiments on the manner in which the cohesion of rock-salt varies

* Poggendorff's 'Annalen,' 5th May, 1869.

in several crystallographic directions.* Small rectangular prisms were cut from the salt of Stassfurt, having their axes normal to the faces of various crystalline forms. The tenacity of the prism was then determined by attaching a scale-pan, and loading it until fracture occurred. It was thus found that the prism always broke along a plane parallel to the face of a cube, but that the breaking strain varied considerably, according to the direction in which the prism had been cut.

In working the Jacobsglück lode at Andreasberg in the Hartz, a peculiar and extremely rich *argentiferous sand* has lately been found.† The lode contains many drusy cavities irregular in shape and variable in form, the larger ones being usually empty, whilst the smaller ones are filled with sand. By examination under the microscope and before the blow-pipe, this sand is found to contain native silver in minute octohedral crystals, and in scalenohedral forms probably pseudomorphous after calcite. It is notable that silver does not occur crystallized elsewhere in the Andreasberg district; while, on the other hand, red silver ore, which is a common mineral in the veins, is absent from the sand. The pulverulent material contains, however, chloride of silver in very small cubes; and this, strangely enough, never occurs crystallized in the mines, and is, indeed, a rare mineral in the district. Calcite, quartz, and a yellow amorphous mineral not yet determined, complete the list of constituents of this true "silver sand."

Among the many rich gold-bearing veins of the Maldon Mining district in Victoria, few have excited more interest than the "Nuggetty Reef." Mr. Salter, the manager of the Alliance Company's mines, has detected in this lode a peculiar metallic mineral, which in the hands of Mr. Ulrich turns out to be a new species.‡ *Maldonite*—as we are to call it—occurs as a silver-white, slightly pinkish mineral, with a bright metallic lustre rapidly tarnishing. It is softer than pure gold, very sectile, and exhibits apparently a cubic cleavage. Its chemical examination showed it to be an alloy of bismuth with gold.

From the copper mines of Namaqualand Mr. Gregory has obtained a mineral, which Professor Church has described under the name of *Namaqualite*.§ It occurs in thin layers made up of short silky fibres, exhibiting a pale-blue colour, and consisting, apparently, of a "cupric aluminic hydrate," thus formulated:— $Al_2\ H_6\ O_6.\ 3\ Cu\ H_2\ O.\ 4\ aq.$

Jakobsite is Damour's name for a new species related to the spinel group, found in the mines of Jakobsberg, in Wermland,

* Poggendorff's 'Annalen.' 1869. No. 6, p. 177.
† Leonhard u. Bronn's 'Jahrbuch.' 1869, p. 445.
‡ 'Notes on the Nuggetty Reef,' Maldon, Victoria. By G. H. F. Ulrich, F.G.S.
§ 'Chemical News,' July 30, 1869, p. 53.

Sweden.* It is a black, lustrous, magnetic mineral, crystallizing in octohedra, having a specific gravity of 4·7, and a composition expressed by the formula:—

$$(MnO, MgO) (Fe_2 O_3. Mn_2 O_3).$$

From Nischne Tagilsk, in the Urals, a sky-blue compact mineral has been examined by M. Hermann, and described as a new species under the name of *Cyanochalcite.*† It is composed of phosphate and silicate of copper, thus represented:—

$$4 (Cu O. PO_5 + 9 (Cu O. Si O_2) + 19 HO.$$

A new ore of the rare metal tellurium has lately been found in the Sierra de Tapalpa, in Mexico.‡ Professor del Castillo transmitted a specimen to Rammelsberg, whose analysis leads to the formula: $Ag_2 S Bi_2 Te_2$. Such a substance might, of course, be a mixture of minerals, but Rammelsberg himself believes it to be a definite compound, and therefore a new species.

The same active chemist has also been at work on the composition of several native silicates, including chabazite, stilbite, desmine, mesotype, scolecite, and serpentine.

Some crystals of smoky quartz of gigantic proportions have recently been found in a difficultly accessible part of the Canton Uri, in Switzerland, and the details of the discovery have been published by Dr. Fellenberg.§

In optical mineralogy it will be sufficient to call attention to Dr. Kossmann's elaborate paper on the peculiar lustre and dichroism of hypersthene.‖

10. MINING AND METALLURGY.

MINING.

THE Mines Inspection Bill, which may be regarded as an example of that uncertainty which ever attends all attempts at legislation when individual interests are forced into opposition to the ends in view, has, at the last hour, been postponed for another year. Twelve Inspectors are left, as before, to look after the safe condition of upwards of 3000 collieries; and the coal miners remain still at the mercy of that superintendence which, sometimes good but often imperfect, has prevailed during the past years which have witnessed

* 'Comptes Rendus,' July 19, 1869, p. 168.
† 'Journal für praktische Chemie,' 1869, p. 65.
‡ 'Zeitschr. d. deutsch. geolog. Gesell.,' xxi., p. 81.
§ 'Berner Mittheilungen,' 1869, p. 135.
‖ Leonhard's 'Jahrbuch,' 1869, p. 532.

annually the sacrifice of about a thousand human lives in the production of upwards of 100 millions of tons of coal.

As the last act of this drama for the year, Lord Elcho called the special attention of the House of Commons to a memorial signed on behalf of 30,000 miners, "praying for a special inquiry into the recent accidents in coal-mines, that have resulted in great loss of life." To this Mr. Secretary Bruce's reply is worthy of preservation:—"It was natural that the workmen, whose lives were constantly threatened, should look to the Government for protection from dangers, and, within proper limits, the Government ought to grant them that protection; but, at the same time, the workmen ought themselves to co-operate. Their occupation was attended by peculiar dangers, from which no Government could wholly exempt them. By the co-operation of the men those dangers might be much lessened; but, in the absence of such co-operation, he altogether despaired of seeing a reduction in the number of lives lost in consequence of accidents in mines. The Government ought to have in every locality a certain number of competent men to listen to every warning and rumour of danger, but it was no *part of their duty to examine personally into the state of every colliery!*" It is part of their duty to inspect every infant school to ascertain if the teacher is competent, and to grant money for its support, but the lives of colliers, often placed at the mercy of ignorant men, are of no moment. So says the Home Secretary!

A conference of delegates from various associations of coal-miners was held in Manchester on Monday the 23rd August. At this meeting the delegates advocated, with their usual indiscretion, the eight hours system, and, as it appears to us, indulged, most unfortunately, in a series of misrepresentations regarding the Government Inspectors and the Colliery owners. Desiring above all things that the rights of labour should be acknowledged, we cannot but feel that the endeavour now so constantly made by the delegates to sow the seeds of evil between the employer and the employed is only postponing for an indefinite period the end desired. The miners' grievances are many; but it must never be forgotten that the miners have duties as well as grievances, and that the removal of the one depends greatly upon the faithful performance of the other. At the meeting to which we have referred, it was urged that all the blame regarding accidents rested with the masters, who were, whenever an accident happened, to be convicted of manslaughter, if not of murder. Is it possible that the speakers could have been ignorant of the positive wilfulness of the men themselves, who, in defiance of all the rules, act as if they believed they had some especial immunity from danger? Let us hope that in time some better system of training will place the coal-miner beyond the injurious influences of men who so sadly misrepresent the truth.

The discovery of a new coal-field in India has been exciting considerable attention. The following remarks from one of the Calcutta journals will be read with interest:—

"There has been a great 'find' of coal in the Central Provinces, and I beg the attention of the Great Indian Peninsula Railway to the fact. The district of Chanda lies due south of Nagpore, between that and the river Wurdah, which forms the northern boundary of Hyderabad. For some years Captain Lucie Smith, the Deputy-Commissioner, has been boring for coal; and Mr. Mark Fryar, the practical geologist sent out lately to report on our coal resources, has more than confirmed his estimate of the value of his discoveries. Mr. Morris, the officiating Chief Commissioner, has written with great caution on the subject, until Messrs. Mather and Platt's steam-borer, which has been sent for, arrives. But ordinary borings and the opinions of Mr. Medlicott—Geological Surveyor under Dr. Oldham, who is Director-General of the Indian Geological Survey—Mr. Bonner, C.E., and Mr. Fryar, reveal a vast and thick and uniform deposit of coal, which has led the last to urge Government to begin mining operations at once, and to make a branch railway to the main Great Indian Peninsula line. The sandstones of the Chanda basin are the same as the well-known coal-bearing sandstones of Raneegunge, to which, indeed, Mr. Fryar compares the deposits in value and extent. He is confident that there are at least two square miles of coal 14 feet thick at a depth of 300 feet, and in easy working position, on the Chanda side of the Wurdah, while there is a certainty of more than the same area on the other side. This practical Government geologist declares that the coal can be laid down, by branch railway, at Nagpore at 1*l.* per ton, giving a profit of 10*s.*, while a ton of English coal costs 1*l.* 16*s.* at Bombay, and double that at Nagpore. If we so far discredit the Chanda coal as to say a ton of it is equal to only half a ton of English coal, it will still have 16*s.* in its favour at Nagpore. All India at present turns out 600,000 tons of coal a-year—not more than the produce of one good colliery in England; and the two square miles of Chanda coal would give the same supply for thirty years. Labour is abundant; the mines would prove a boon to a poor population. This is not all. The finest, if not the largest, cotton mart in India lies between Chanda and the main line of railway. That is Hingunghat, the cotton of which is so good that its seed is being introduced wherever the Sea Island and Egyptian varieties do not suit the inland climate. The Chanda coal-field is to the south of Hingunghat, and to the north of the finest cotton districts of Hyderabad. Cross the Wurdah to the south and you come to Edulahad, the cotton of which is so good that an English merchant has just laid out 10,000*l.* there, intending to send the produce down the river Godavery, of which the Wurdah is the main

affluent, to Coconada. A branch line for the cotton alone was long ago projected to Hingunghat. Now there is the coal. If even half of Mr. Fryar's expectations are realized, the least known part of India will be opened up, and the feudatory provinces of the Nizam, who will be a minor for the next fourteen years, will be enriched, while they are made to contribute their wealth of cotton and coal to the general good."

Mr. Mark Fryar has recently published a letter "On Coal-Mining in India," addressed to the "proprietors and managers of coal-mines in India," which cannot but produce a beneficial result in directing attention to improved methods of working the coal-mines.

In connection with this subject of coal-mining, Mr. Henry Bessemer, who is well known for his process of manufacturing steel, has—in devising a process for the production of a most intense heat for metallurgical processes—been led to suggest a modified form of that arrangement for lighting mines.* By combustion under pressure, Mr. Bessemer obtains the most intense heat, and the most vivid light, "a light that never fails, that never goes out, that never requires trimming, and, above all, a light that effectually prevents the mixture of air and gas which pervades all coal-mines from entering the flame and becoming ignited. Now these are precisely the conditions obtained by combustion under pressure, which offers to the miner a source of the most brilliant light wholly inaccessible to the inflammable air of the mine. As a simple illustration of the fact, let us suppose a small iron box, a little larger than a policeman's lantern, having a thick plate glass or a bull's-eye ono ne side of it; in the lower part is a common gas-burner, supplied by a pipe from a gasometer above ground; the supply of air to support combustion is arranged in a similar manner, and supplied under pressure from above ground; a small aperture is made in the top of the lantern for the escape of the products of combustion. Now, if air and gas are supplied to this light under a pressure of, say 1 lb. per square inch, the light would be brilliant, and the escape from the orifice at this pressure (or even far less) would prevent the possibility of any external gases entering and becoming ignited. In this way every gallery in a mine may be lighted like a workshop, to the great comfort and cheerfulness of those whose whole lives are spent in the cheerless gloom of these dangerous workings."

The mode of advancing the light as the work progresses, and its direction by the use of reflectors, and other necessary details of the system, are simple enough, and need not be here entered into.

In Cornish mining a most decided improvement is evident, consequent upon the increased and remunerative price of tin. The

* See Metallurgical Chronicles.

value of several of the mines near Camborne and Redruth, at the present time, will be seen by the following statement of the monthly labour cost:—

Dolcoath	£2600	paid in August for	Wages
Pendarves United	1800	"	"
West Seton	1400	"	"
Wheal Seton	1100	"	"
Tin Croft	1050	"	"
Cook's Kitchen	1000	"	"

In round numbers, 15,000*l.* a-month are now paid in wages by twenty-one mines in the Camborne district only.

The mineral wealth of Portugal appears to be developing itself in a somewhat remarkable manner. In 1853 there were but two mines in the kingdom, there are now

23 Coal mines	66 Lead and Silver mines
45 Iron "	85 Manganese "
98 Copper "	6 Gold "
29 Tin "	6 Antimony "

There are now altogether, in full operation, 220 mines.

The mining industry of Queensland is rapidly acquiring increased importance. In 1867 the value of the gold exported was 189,248*l.*; in 1868 it reached 593,616*l.* The value of the exports of copper and copper-ore have increased during the same period from 66,038*l.* in 1867, to 72,136*l.* in 1868.

Copper in Belgium.—In the neighbourhood of Vielsalm, in the province of Liège, some drainage works were in progress, when at no great depth beneath the surface a piece of native copper weighing about 2 kilos. was found. It was partly hollow, and exhibited a crystalline structure. A further search was made, and some veins of malachite were discovered.

Mr. Ball, of the Geological Survey of India, has communicated to the Asiatic Society some interesting notices "On the Ancient Copper Mines of Singhbhúm." As a contribution to the history of mining, this paper is of considerable value. Those mines were probably worked about the same time as those of the Sinaian range, and probably served with them to supply the copper to form the bronzes which were so largely used when the great Eastern monarchies were in their glory. Mr. Bauerman has lately described, in the 'Quarterly Journal of the Geological Society,' the copper mines of Arabia Petræa.

The following remarks from the address of Sir Wm. Armstrong at the Newcastle Meeting of the Institution of Mechanical Engineers have, at the present time, a peculiar interest:—"England, with her innumerable steam-engines and manufactories, is more dependent upon coal for the maintenance of her prosperity than any other nation; and the question of the duration of her coal-fields, now, very properly, occupies the attention of a Royal Commission. The investigations of that commission are not yet completed, but, so far

as they have gone, the results are re-assuring. I concur in the probable accuracy of the announcement lately made by two of my fellow commissioners, that the total quantity of coal in this island will prove to be practically inexhaustible; but until the complicated details of quantities collected by the commission have been put together, and expressed in totals, it is difficult to judge with certainty or accuracy on the subject. Although the duration of our coal may, geologically speaking, be practically unlimited, we have still to consider the important question, How long will England be supplied with coal as good and as cheap as at present? We have unquestionably made greater inroads into our best and most accessible coal-beds than other nations have done into theirs; and if foreign coal should grow better and cheaper, and ours dearer and worse, the balance may turn against us as a manufacturing country long before our coal is exhausted in quantity. It is clear that our stock of good coal is very large, but most of it lies at great depths; and one of the most important questions the Royal Commission has to investigate is the depth at which coal can be worked with commercial advantage. The chief obstacle to reaching extreme depth is the increase of temperature which is met as we descend. I am justified, by ascertained facts, in saying that this rate of increase will, as a rule, prove to be not less than 1° Fahrenheit for every 20 yards in depth, and there is reason to expect that it will be even more rapid at greater depths than have yet been attained. The constant temperature of the earth, in this climate, at a depth of 50 feet, is 50°; and the rate of increase, as we descend, is to be calculated from this starting-point. Adopting these figures, you will find that the temperature of the earth will be equal to blood-heat at a depth of about 980 yards, and at a further depth of 500 yards, mineral substances will be too hot for the naked skin to touch with impunity. It is extremely difficult to form an opinion as to the maximum temperature in which human labour is practicable in the damp atmosphere of a mine, and it is almost equally difficult to determine how much the temperature of the air, in the distant part of an extremely deep mine, can be reduced below that of the strata with which it is brought in contact. It is certain, however, that the limit of practicable depth will chiefly depend upon the mechanical means which can be provided for relieving the miners of the severest part of their labour; for maintaining a supply of sufficiently cool air at the working faces of the coal; and for superseding the use of horses, which suffer even more than men from highly-heated air. For the relief of labour we must look to coal-cutting machines; for improvement of ventilation to exhausting fans; and for the superseding of horses, to hauling engines driven by transmitted power. The employment of coal-cutting machines, working by compressed air, conveyed into the mine by

pipes, is already an accomplished fact; and when the difficulties and objections which usually adhere for a considerable time to new mechanical arrangements are removed from these machines, they will probably attain extensive application."

METALLURGY.

Mr. Henry Bessemer has recently patented a means of producing heat, which is of a very remarkable character. The principle involved will be understood from the following remarks by the inventor:—"I am at the present time busily engaged in investigating the action of combustion under pressure in furnaces where the flame is bottled up (so to speak) like steam in a steam-boiler, by which means heat is intensified in the ratio of the pressure employed, so that the most refractory substances known to man may be fused or dissipated in vapour with the same quickness and facility with which our most fusible substances are melted. In one modification of these furnaces the workmen operate in a large iron room, where the pressure of the atmosphere is greater than it would be at a depth of ten miles below the surface of the earth, and where the temperature, under ordinary circumstances, would be such that no attendant of a Turkish bath could endure it for a single hour. Yet these men and the furnace they tend may, by a simple arrangement of apparatus, be supplied with thousands of cubic feet of air per minute, as cool, or if necessary much cooler, than the surrounding atmosphere."

The following new process for obtaining iron from its ores has been brought before the Academy of Sciences by M. Ponsard. The author of this paper has applied Siemens's furnace to the manufacture of iron; he states that he has succeeded in producing one ton of cast iron, of excellent quality, with a consumption of only one ton of fuel. The author summarizes his results in the following manner:—

(1) A great saving of fuel can be made, and iron obtained from its ores, without the use of blast furnace; (2) that, since the heat produced by flame is sufficient to effect all the chemical reactions and melt the metal, there may be used all kinds of fuel which produce gas—that is to say, all kinds of coal, no matter whatever their quality, wood, lignite, peat, hydrogen gas, and mineral oils; (3) it is possible to obtain, at will, a more or less carburetted metal, according to the quantity of carbonaceous matter which is mixed with the ore, and placed in the crucibles to act as chemical agent only. Specimens of iron, of very good quality, obtained by the process as carried on by the author, were exhibited to the members of the Academy at this meeting.

11. PHYSICS.

LIGHT.—A diaphanometer to determine the transparency of different kinds of glass has been devised by M. Jicinsky. Without the engravings, it is impossible to make this instrument understood. The author has proved that the diaphanicity of divers kinds of glass is not dependent so much on its chemical composition, as on certain physical properties due to the heat applied in making it.

Physicists and others engaged in optical studies will feel interested in hearing that there has been a discovery of large crystals of quartz in a difficultly accessible portion of the Swiss Alps; one of these weighs 267 lbs., is 69 centimètres in height, and has a circumference of 122 centimètres.

The employment of the spectroscope to distinguish a feeble light present with a stronger light, has been suggested by M. Seguin. The author describes a series of experiments with electric light, and observations thereon with Duboscq's vertical spectroscope. The conclusion arrived at is that the spectroscope eminently serves the purpose of detecting a feeble light present along with a much stronger one, the former of which would be invisible to the naked eye, or by means of other optical instruments.

The zirconia light is attracting great attention on the Continent. The chief desideratum in oxyhydrogen illumination of this kind is the cheap production of oxygen; and the process of M. Tessie du Mothay, according to the Paris correspondent of the 'British Journal of Photography,' appears to be all that can be desired so far as cheapness and efficacy are concerned. It consists in heating in iron retorts, divided in two by a horizontal grating, a quantity of manganate of soda. This is raised to a dull red heat, and a current of superheated steam is made to pass over the mass. Oxygen is given off in abundance and passes along with the current of steam into a refrigerator, where the steam is condensed into water, and the oxygen is afterwards collected in a gasometer. The next operation is to re-oxygenize the exhausted manganate. This is accomplished by passing heated *air*, not steam, over it, when the manganate absorbs the oxygen, and becomes as ready as ever for yielding it again to the vapour of water. Thus the two operations can go on for an indefinite time, the air being the source of supply of oxygen. One advantage claimed by the advocates of the zirconia cylinders, besides their durability, is that a mixture of *equal* parts of oxygen and carburetted hydrogen can be used instead of a mixture in which oxygen is in excess, as is usual. There are large oxygen gas works for carrying out this method now erected in New York. The essential portions of the process are carried on by the aid of brick furnaces, of which only one was in operation at the

time of our informant's visit, several others being, however, rapidly fitted for use. Each furnace has its fire-box so arranged as not only to heat the retort which holds the manganate of soda, but also one or more chambers through which an air-blast passes to the retort. The retort furthermore communicates, by a pipe furnished with stop-cocks, with a suitable steam boiler. About 600 pounds of manganate of soda are placed in the retort, heated to the requisite degree in the furnace; su erheated steam from the boiler is then admitted for about ten minutes. Two equivalents of the manganate of soda and two of water react upon each other, and the operation proceeds as described above.

A method of coating glass, porcelain, or earthenware, with a thin film of lustrous metallic platinum, has been published by Prof. Bœttger. Dry chloride of platinum, freed from excess of acid, is mixed in a small porcelain mortar, with essential oil of rosemary, until the original brown-red colour of the salt has entirely disappeared, and has been converted into a black pitch-like looking mass. When the pitch-like mass has been obtained, the oil is entirely removed, and the pasty mass is mixed with at least five times its weight of lavender oil, and mixed therewith to a homogeneous fluid; this, after having been quietly standing for half-an-hour, is applied with a hair brush on the glass or porcelain objects to which it is desired to give a coating of lustrous platinum, and after the very thinly and evenly laid on film is dry, the objects are either placed in a red-hot muffle, or heated in the flame of a glass-blower's lamp, care being taken not to exceed a red heat.

According to M. Grimm, chloride of copper completely removes even from coloured woven cotton tissues, stains occasioned by nitrate of silver; the tissue is to be afterwards washed with a solution of hyposulphite of soda, and next thoroughly washed with water. From white cotton and linen tissues, nitrate of silver stains are more readily and effectively removed by applying dilute solutions of permanganate of potassa and hydrochloric acid, followed by washing with hyposulphite of soda solution, and rinsing in plenty of fresh water. By these means the use of the highly poisonous cyanide of potassium is rendered unnecessary.

HEAT.—In the course of an introductory lecture on the occasion of the opening of the new laboratories at Berlin, Dr. Hofmann, F.R.S., illustrated some new experiments with flame, which he had devised for the purpose of showing its structure. Take a piece of canvas and put it on to the top of the glass chimney of an argand gas-burner, taking care to envelop the glass chimney previously with a very thin piece of copper foil, while the access of air at the bottom of the burner should be as much as possible prevented. On turning

the gas on, it escapes readily through the small openings in the canvas, and the gas may be ignited above. The canvas, however, soon takes fire and burns off, but leaves a very complete circular disc, which remains white and unconsumed in the centre of the flame. If it is desired to demonstrate more completely the nature of the flame, it is done by placing on the middle of the canvas disc some gunpowder, and on it the heads of some lucifer matches. After having again turned on the gas, and left it to escape for a few moments, it may be kindled again, and will burn quietly; and even though, as in the first experiment, the excess of canvas again burns off, neither the gunpowder nor matches will catch fire until just at the moment the gas is gently turned off.

M. W. Stein states that the vapour of perfectly pure disulphide of carbon is not decomposed when passed through a red-hot porcelain tube; but on repeating the experiment and increasing the heat by the application of a strong coke and charcoal fire, the inner space of the tube having been filled with broken porcelain, it was found to be lined with a deposit of carbon, owing to the decomposition of the sulphide, while sulphur was collected in a receiver.

While engaged with experiments on the intrinsic composition and constitution of various pieces of silver money, made at the Royal Netherlands Mint at Utrecht, Dr. A. von Riemsdyk carried on some experiments on the fusibility and volatility of metals. The author found that there does not exist any relation at all between the fusibility and volatility of metals, which may be arranged in the following manner, beginning from the most fusible and most readily volatile:—

	Fusibility.	Volatility.
Tin	228°·5 C.	Cadmium.
Bismuth	268°·3 „	Zinc.
Cadmium	320°·0 „	Bismuth.
Lead	326°·0 „	Lead.
Zinc	420°·0 „	Tin.

Silver melts at 1040° C., pure gold at 1240° C., while the author found that chemically-pure copper requires a temperature of 1330° C. to become liquid. Neither pure silver nor pure copper loses anything at all by volatilization when kept for a considerable time at temperatures higher than the melting-points of both these metals, and in a feeble current of pure hydrogen to prevent their oxidation. The author has made some of these experiments on a very large scale, having at his disposal several hundred kilos. of these metals in pure and alloyed state.

ELECTRICITY.—It may be of some interest to our readers to know the theory which has been formed by the Rev. Father Secchi, S.J., on electricity. He writes, in a letter to M. F. Mazco, at Turin,

"I believe that the true theory of electricity will result from the principle that electricity is not a motion (*mouvement*), but a change of the quantitative and dynamic equilibrium of the ether which constitutes the atoms of the substances, and that the propagation of such a change is brought about by the moving of the ether from one atom to another; this motion shakes, disturbs the ether of the atoms, and thus produces heat."

An electrical phosphoroscope has been described by M. Laborde; its essential parts are a Ruhmkorff induction apparatus, the spark of which throws light on the phosphorescent object, and of a sliding frame, one of the ends of which hides the object during the brief moment it is illuminated by the electric spark. This sliding frame is 40 centimètres in length, by 10 centimètres in breadth; it is fixed at its centre on an axis, which may be made to move rapidly by means of a pedal. The arrangement of this apparatus is such as to render it serviceable for studying the phosphorescence excited by a blow, as well as by friction. The phenomena of phosphorescence of substances which, like nitrate of uranium, are only of very short duration, can be observed by means of this instrument equally well as the long-continued and strong phosphorescence induced by friction in pieces of porcelain or glass.

MM. Mure and Clamond have made a thermo-electric battery with galena. It is composed of [illegible]ty elements, made up of small bars of galena, 40 mm. in length by 8 mm. thick, and bars of thin sheet iron, 55 mm. in length by 8 mm. in width, and 0·6 mm. in thickness. These materials have been arranged so as to form a hollow cylinder, which, when it is intended to be used, is to be heated by a peculiarly constructed gas-burner. The specimen of this battery exhibited at a meeting of the French Academy had an electro-motive force of 1½ Bunsen element. M. Becquerel read a lengthy paper on the subject of this battery, the result of which is that thermo-electric batteries constructed either of metallic alloys, or, as in this case, of a metallic sulphide and a metal, are not economical in use, and are too liable to changes brought on by the effects of the heat.

M. J. Meunier proposes to make use of the well-known experiment of Leichtenberg's electric figures to separate from each other the divers mineralogical constituents of some kinds of rock. We briefly remind our readers that the experiment alluded to consists in charging with electricity a cake of resin or sealing-wax, by means of a previously-charged Leyden jar; it is thus possible to charge certain portions of the cake with positive, others with negative, electricity. In order to exhibit this to sight it is usual to blow, by means of a small pair of bellows, on to the cake of resin, a mixture of very finely-powdered red-lead and sulphur; the friction on

leaving the nozzle causes the powders to become electrified, and the sulphur being negatively electric is attracted by the curved figures positively electric on the cake, while the red-lead follows the opposite course. M. Meunier has tried thus to separate sulphur-bearing trachite into its mineral constituents, and succeeded perfectly in getting the sulphide and feldspar from each other: he states that he has succeeded equally well with rocks made up of two different silicates.

12. ZOOLOGY—ANIMAL PHYSIOLOGY AND MORPHOLOGY.

Physiology.

The Temperature of the Human Body.—Mr. Alfred H. Garrod, of St. John's College, Cambridge, has made (and communicated to the Royal Society) a series of observations on a human "subject, aged 22, male, thin," whom we take to be himself, by means of very delicate thermometers and the sphygmograph, which he considers show that the minor fluctuations in the temperature of the human body, not including those arising from the movements of muscles, mainly result from alterations in the amount of blood exposed at its surface to the influence of external absorbing and conducting media. It has long been known that cold contracts and heat dilates the small arteries of the skin, respectively raising and lowering the arterial tension, and thus modifying the amount of blood in the cutaneous capillaries. But modifications in the supply of blood to the skin must alter the amount of heat diffused by the body to surrounding substances; and so we should expect that by increasing the arterial tension, thus lessening the cutaneous circulation, the blood would become hotter from there being less facility for the diffusion of its heat; and that by lowering the tension, thus increasing the cutaneous circulation, the blood would become colder, throughout the body, from increased facility for conduction and radiation. Thus the temperature and tension rise together on stripping off the clothes in a cold air—the temperature and tension fall by covering even a part of the body when stripped; simply heating the feet lowers the tension and the temperature of the body together. Mr. Garrod gives his observations very carefully, in numerous neatly-constructed tables, and appears to have well established his point. He remarks that the fall in the temperature of the body at night observed by Dr. Ogle, and by Drs. Ringer and Stewart, which is lowest at from 12 to 1 A.M., and rises after that time, is due to the fact that Englishmen go to bed

at about that hour and give up heat to the bed-clothes. Another explanation he offers has a practical importance for every reader. On a cold day the effect of sitting with one side of the body in the direct rays of a fire is to cause the other side to feel much colder than if there were no fire at all, because the fire lowers the tension all over the body, and supplies heat to the full cutaneous vessels of one side, while the other side being equally supplied with blood in the skin, does not *receive* heat, but has to *distribute* it rapidly to the cold clothes, &c. It should be mentioned that Mr. Garrod takes the temperature beneath the tongue, and that the variations recorded are all between 97° and 100° Fahr.—the variation of a tenth of a degree being readily recognized. Some interesting results of a similar nature might be obtained as to the cause of still smaller fluctuations by means of the thermo-electric scale.

The Cause of the Rouleaux of Blood Corpuscles.—Dr. Norris, of Birmingham, has recently repeated to the Royal Society the explanation of the phenomenon of the aggregation of the blood corpuscles which he put out in a former paper in 1862, and has exhibited his very ingenious and conclusive experiments. Dr. Norris constructed discs of cork of the shape of blood corpuscles, and found that when thrown into water they aggregated in the same *rouleaux* as do blood corpuscles. But he found that this result could not be maintained if the discs were perfectly submerged: hence there was a considerable difference between the case of the discs and of the corpuscles, which, of course, *are* submerged. At length Dr. Norris found that if he wetted the discs of cork or gelatine with which he experimented, and then placed them in a liquid which would not mix with the water, that the *rouleaux* were formed quite satisfactorily, even when the discs were submerged. The formation of *rouleaux* then depends on cohesive attraction—but on the cohesive attraction of *two* interacting bodies—in all Dr. Norris's experiments, and in the blood there are two dissimilar or antagonistic liquids; and upon the presence of these two the phenomena depend. The air acts the part of one of these in the case of *floating* discs. All that is required in the case of the corpuscles is a difference of this kind, between their liquid contents, as Dr. Norris prefers to say, or their viscous substance, as others may term it, and the plasma in which they are submerged. The difference need not be so great by any means as the difference between the liquids used in Dr. Norris's experiments (water and paraffin), since the corpuscles are so excessively minute.

The Movement of the Chest in Respiration.—Dr. Burdon Saunderson has constructed an ingenious instrument for measuring the frequency and intensity of the respiratory pulse, as it may be termed. Other physiologists have tried in various ways to con-

trive an instrument which should do this, but Dr. Saunderson has certainly improved upon all previous attempts. A large square pair of calipers made of steel forms the part of the instrument which grasps the chest, and which can be moved or adjusted to any particular size. The movements of the chest are made to press against a spring placed inside the arm of the calipers, and by the movement of the spring an india-rubber sack containing air is compressed. By a well-known and most ingenious device the compression of the air in the first sack is communicated through an india-rubber tube to a second larger sack placed at a convenient distance, and there the motion is transferred to a delicately-balanced lever, which being furnished with a brush and ink at its long extremity, writes off the movement on a regularly rotating cylinder. The advantage of this instrument is that it gives the whole movement of the chest in one line—the wall of one side of the thoracic cavity acting as a fixed surface in consequence of the calipers being applied to opposite sides. An important feature is, that so delicate is the spring and elastic sack apparatus, that the instrument acts as a cardiograph as well as a recorder of respiratory movement. The consequence is that the tracings from the revolving cylinder present two sets of curves: a large series, belonging to the movement of the thoracic walls; and a smaller set, due to the heart's impulse. Thus by this instrument one is enabled most clearly and satisfactorily to observe the relations of these two sets of movements and their interaction. Dr. Saunderson finds that this instrument confirms the observations which he formerly made with less satisfactory apparatus.

The Movement of the Wings of Insects in Flight.—M. Marey, perhaps the most original physiologist which France has produced in our time, has applied himself to the study of the movements of the wings of insects during flight. By gilding the tips of the wings of a hymenopterous insect, he was able to render it sufficiently brilliant to permit the eye to follow its movement, and he perceived that the tip of the wing described a figure of eight in its upward and downward movement. By applying a piece of sooted glass to the wing, he was able to get this movement marked off on a piece of glass. Now, to describe such a curvature combined with the flapping movement, supposing the wing to be a rigid body, would, M. Marey demonstrates, require a most complex arrangement of muscles, especially to produce such a movement with the great rapidity with which it occurs in the insect's wing. But the fact is that this "feathering" action of the wing is due merely to the up and down movement of the wing, coupled with its peculiar form and elasticity. M. Marey has made a model with wings, having one side rigid and the other tense but elastic, and he finds that on imparting a simple movement to these wings at their point

of attachment, exactly the same figure of eight is described as in the case of the real insect, and a propelling force is obtained sufficient to make the model move rapidly on a pivot.

Morphology.

The Structure of the Organs of Taste in Man.—The existence of a peculiar terminal apparatus in each organ of special sense is now become an indubitable fact. This terminal apparatus has been studied with care for the organs of touch, of smell, of hearing, and, above all, of sight; but we were up to the present time in complete ignorance of the mode of termination of the gustatory nerve-fibres in the tongue. It is therefore very gratifying to find that, independently, two anatomists, Dr. Schwalbe and Dr. Christian Lovén, have studied this matter, and arrived at closely concordant results. The gustatory nerve-fibres by common consent have their terminations in the so-called *papillæ vallatæ*, and these are variously disposed in different mammifers. Their structure is complex, enclosing as a rule acinate glands, whilst the epithelium covering them is much thinner than that on the rest of the tongue. It is on the walls of the mote surrounding the papilla that it is thinnest. The gustatory organs discovered by Drs. Lovén and Schwalbe may be called gustatory bulbs. They occur only in the wall of the papilla limiting its circumscribed fossa. Each bulb, enclosed in an epithelial stratum, rests by an attenuated extremity directly on the mucous layer properly so called. Its form is that of a thick spindle, and the epithelium of the surface of the wall of the papilla is punctured by openings, each of which corresponds to the point of a gustatory bulb, so that by means of these apertures the gustatory bulbs are placed in direct communication with any fluids which may accumulate in the mote of the circumvallate papilla. The structure of the gustatory bulbs themselves is somewhat complex, but they contain elongated *bâton*-like cells, such as have been found in other special-sense organs. The nerve-fibres of the gustatory nerve lose their double contour before becoming united with these terminal organs, and the union is simply, as in other organs, between the naked axial cylinder and the elongate gustatory cells which make up the gustatory bulbs. Although in many cases these bulbs are restricted to the papillæ vallatæ, yet Dr. Lovén remarks that in some animals (man, sheep, and others) he has found them in some of the fungiform papillæ.

Professor Claparède's Writings.—The industry and skill of the Professor of Comparative Anatomy at Geneva are calculated to excite the highest admiration. It is only within the year that he has published a magnificent volume 'On the Annelids of the Bay

of Naples,' and he now appears again, first with an essay—written in German this time (he writes equally well in that language or in French)—entitled 'Studies on Acarids,' illustrated with eleven coloured folding plates; and secondly, with a joint paper in association with Professor Elias Mecznikow 'On the Development of Chætopodous Annelids,' illustrated with six coloured plates; besides these, he has in the press an extensive memoir 'On the Anatomy of the Earthworm.' Nothing could more clearly show the importance to the naturalist of possessing skill with the pencil than these beautiful labours of Professor Claparède. He is able rapidly to note down his observations by this means, and the very same faculty which enables a man to draw what he sees, makes him, at the same time, more apt at disentangling the intricacies of a structure, and more rapid and certain in his observation altogether. The 'Studies on Acarids' is perhaps the more important of the two works we have mentioned, since the development of several species is accurately and carefully detailed and figured; whilst the anatomy of several others is given, and some remarks headed "Für Darwin" are appended, pointing out certain arguments in favour of natural selection and descent which may be gathered from this group, as Fritz Müller has so well gathered from the crustacea.

A Living Cystidean.—The Cystidea are a very peculiar group of Echinoderms whose remains are abundant in the carboniferous and other Palæozoic rocks, and they have always been supposed to have become extinct before Mesozoic times. The sensations, therefore, evoked by the announcement of a living Cystidean may be well described as unusual. Yet Professor Lovén calmly describes in a paper only just published, an Echinoderm which he received from Cape York, and which appears to justify his assertion that it is a living Cystidean. In some features it agrees with the living crinoid *Comatula*, but in the fact that the canal between the ambulacral organs is covered in by calcareous plates, it agrees with the Cystidea alone. Further details and figures of this form are anxiously expected. Professor Lovén terms it *Hyponome*. It is worth mentioning, in connection with this, that at the depth of more than a thousand fathoms, Professor Wyville Thomson has, during the last month, dredged an Echinoderm, which he says must be regarded as the type of a totally new division of that group. For an account of his exceedingly interesting letter to Rev. Alfred Norman, read to Section D of the British Association, we must refer the reader to our Report.

Fresh-water Radiolarians.—The beautiful group, some forms of which are known to us as *Polycystina* in Barbadoes earth, which have been so wonderfully worked out by Ernst Hæckel, in his 'Monograph of Radiolaria,' which comprises the *Thalassicolla* of Huxley, and the *Acanthometra* of Müller, and the members of which

are chiefly remarkable for their siliceous spiculæ, or skeleton, and their wonderfully long and delicate pseudopodial threads, have long been thought to have allies in fresh water, in the person of the sun-animalcules (*Actinophrys*). But naturalists who have not watched the record of the proceedings of the Dublin Microscopical Club, published in the 'Quarterly Journal of Microscopical Science,' will have been quite unprepared for the astonishing revelation of several genera of these exquisite forms inhabiting the fresh-water pools on the Irish moors. Their discovery is due to that careful student Mr. William Archer. Dr. Focke, of Bremen, it is true, has this year noticed the occurrence of some of these forms in moor-pools in Germany, but Mr. Archer's notices are much earlier in date than his, though his extended paper is only now appearing. The largest form, which is a truly noble rhizopod, is as big as a large pin's head, with thread-like pseudopods extending to a much greater circumference; masses of siliceous spicula are disposed over the disc, which contains some dozen large spherical bodies of a bright-green colour. This form Mr. Archer names *Raphidiophrys viridis;* other genera are characterized by Mr. Archer, and coloured figures referred to. The chief point of difference between these fresh-water Radiolarians and the marine forms is the absence in the former of the central cyst or capsule, and the yellow cells which have been considered of characteristic importance in the group.

A New Vitreous Sponge.—One of the products of the deep dredging last year, in H.M.S. 'Lightning,' has been described to the Royal Society, by Professor Wyville Thomson, as *Holtenia Carpenteri.* It was dredged up from a depth of 530 fathoms with several other organisms, there being four genera of Vitreous Sponges. *Holtenia* is one of this new group of sponges, which Professor Thomson makes to include also the Ventriculites of the Chalk. The genus is named in honour of Mr. Holten, Governor of the Faroe Islands. The order is mainly characterized by the great variety and complexity of form of the spicules, which may apparently, with scarcely an exception, be referred to the sex-radiate stellate type, a form of spicule which does not appear to occur in any other order of sponges. The genus *Holtenia* is nearly allied to *Hyalonema*, and seems to resemble it in its mode of occurrence. Both genera live imbedded in the soft upper layer of the chalk-mud in which they are supported: *Holtenia*, by a delicate range of siliceous fibres which spread round it in all directions, increasing its surface without materially increasing its weight; *Hyalonema*, by a more consistent coil of spicules, which penetrates the mud vertically and anchors itself in a firmer layer. The vitreous sponges, Dr. Thomson observes, along with the living Rhizopods and other Protozoa, which enter largely into the composition of the upper layer of the chalk-mud, appear to be nourished

by the absorption through the external surface of their bodies of the assimilable organic matter which exists in appreciable quantity in all sea-water, and which is derived from the life and death of marine animals and plants, and in large quantity from the water of tropical rivers. One principal function of this vast sheet of the lowest type of animal life, which probably extends over the whole of the warmer regions of the sea, may probably be to diminish the loss of organic matter by gradual decomposition, and to aid in maintaining in the ocean the "balance of organic nature."

A translation of Fritz Müller's interesting study of Crustacean development, which he published under the title 'Für Darwin,' has been brought out by Mr. Murray, Mr. Dallas having efficiently acted the part of translator.

The British Hydroid Zoophytes, by the Rev. Thomas Hincks, is one of Mr. Van Voorst's beautiful series, and is worthy of its place in that renowned company. The illustrations are in the form of plates—very copious and very well executed by Mr. Tuffen West.

NOTICES OF SCIENTIFIC WORKS.

The Scenery of England and Wales; its Character and Origin, being an Attempt to tra the Nature of the Geological Causes, especially Denudation, by which the Physical Features of the Country have been produced. With 86 *Woodcuts.* By D. Mackintosh, F.G.S. 8vo. Pp. 399. London: Longmans and Co.

This is the title of a new work on Physical Geology by Mr. D. Mackintosh, F.G.S., who has, during the past five years, contributed many original articles upon this subject to the 'Quarterly Journal of the Geological Society,' the 'Geological Magazine,' &c. In pursuing his professional engagements as a lecturer on geology, &c., the author has travelled through the length and breadth of England and Wales, and devoted a large part of his time to making careful observations of all the most striking points of geological interest within his reach.

The book commences with a description of the causes of denudation and the origin of natural scenery in various parts of the world. The second and main portion of the work is devoted to a classification, description, and attempted explanation of the various forms or types of scenery in England and Wales, included under the heads Escarpments, Cwms, Combes or Corries, Passes, Longitudinal Valleys, and Transverse Gorges.

The third part is devoted to excursions to special places of geological interest in England and Wales.

Mr. Mackintosh, by his previous writings, had identified himself as an advocate of "Marine Denudation," and as strongly opposed to the modern school of "Subærialists," as an ultra example of whom we may cite Colonel George Greenwood, who has, in an amusing book (entitled 'Rain and Rivers'*) set forth his views, which are the very antithesis of those of Mr. Mackintosh, but nevertheless contain many excellent observations on Subærial Denudation.

In travelling East or West—from the plain of the Medway to the Great Orme's Head—or from Dawlish and Dartmoor in the South, to Morecambe Bay and Keswick in the North, Mr. Mackintosh points out that, from the present coast-lines to the top of Snowdon, the sea has left its mark on many a Scar and Crag, and that, in fancy at least, we may still hear its murmur in

* 2nd Edition, 1866. London: Longmans and Co.

many an ancient sea-worn cave and hollow now far removed above the roar and turmoil of its surging billows.

We are glad to find that, although Mr. Mackintosh advocates the sea as an efficient agent to produce geological changes, yet he does not ignore the action of other causes in modifying the earth's surface—as Ice, Snow, Frost, Rain and Rivers, Nature's untiring agents, slowly—maybe secretly—yet surely modifying the surface of our island, as certainly as the sea is ever changing the contour of our coasts.

Mr. Mackintosh's previous articles elicited rejoinders from many of our leading geologists, and no doubt his book will have a similar effect.

Some of the woodcuts to this work are very excellent; *e.g.* Wallow Crags;* Sea-worn Chink, Pendower Point;† the Peak of Snowdon (Fig. 31); Cheddar Cliffs, &c.;‡ others owe their merit to their utility as diagrams; a few might be better drawn, the subjects being really fine, if well treated.

In a future edition we would suggest the elision of several pages in Book III. ("Excursions"), which are merely irrelevant §, and the substitution of a short "Itinerary," giving plain directions how best to reach the many places of geological interest mentioned by the author.

It is almost too late this year for the home tourist to avail himself of Mr. Mackintosh's guidance to the Welsh Mountains, or Coniston Crags, but no doubt next year he will find many of our readers who will gladly take a walk with him "over Malvern Wych at midnight" (although, as keen geologists, they might prefer the early dawn), or, knapsack on back, to start "from Llanberis to Snowdon, through the Pass, and by Llyn Llydaw,"—or, indeed, along any of the twenty routes he has laid down for their acceptance—sure of finding fresh air, hard walking, capital scenery, good appetites, and some very hard geological nuts to crack afterwards.

Spectrum Analysis.—Six Lectures delivered in 1868 before the Society of Apothecaries of London. By H. E. Roscoe, B.A., F.R.S. Macmillan and Co., 1869.

This is the most complete work on spectrum analysis which has yet appeared in the English language; and the author being one of the first popularizers of this branch of experimental analysis, is thoroughly competent to deal with all the varied ramifications into which it has branched of late years. Little was heard of spectro-

* P. 382. † P. 55. ‡ P. 141.

§ *e.g.* pp. 303–4, "An episode," &c.; p. 299, "Unfounded Suspicions," and one or two other passages.

scopic researches until Professor Roscoe communicated to the 'Philosophical Magazine' Messrs. Bunsen and Kirchhoff's paper, in which they announced the probable existence of some new elements discovered by its means; but since then, spectrum observations have been deemed one of the most powerful means of research, and have formed an intimate bond of union between two sciences which before had little in common—astronomy and chemistry. The book is based, as the title indicates, on a course of six lectures delivered in 186[illegible]; but it must by no means be concluded that the author has merely printed the lectures as delivered. They are not only rewritten, but a large amount of new matter—which could not well be compressed into the substance of an hour's lecture—is introduced in the form of an appendix, which is often longer than the lecture itself; references which were originally brief are here quoted in full; discoveries which have been made since the delivery of the lectures are incorporated with the text; and illustrations, whether diagrammatic or experimental, appear in the form of woodcuts and chromo-lithographs.

The first lecture is somewhat elementary, being devoted to the properties of light, the action of a prism, the various conditions of different portions of the spectrum, and an account of the fixed black lines which cross it. In the second lecture the ordinary phenomena of spectrum analyses as usually understood are described, and its marvellous delicacy, which is capable of appreciating the 180-millionth part of a grain of sodium, is enlarged upon. The description of the spectroscope and its uses concludes this lecture.

The third is a continuation of the same subject, and includes an historical sketch of the development of spectrum analysis, and an account of the four spectrogenic metals—cæsium, rubidium, thallium, and indium. Some practical applications of spectrum observations are here given, including a very full account of the employment of the spectroscope in the determination of the right moment to stop the blast during the Bessemer process. Speaking of this, we are told that if the blast be continued for ten seconds after the carbon lines disappear from the field of view, or if it be discontinued ten seconds before that point is reached, the charge becomes either so viscid that it cannot be poured from the converter into the ladle from which it has to be transferred to the moulds, or it contains so much carbon as to crumble up like cast iron under the hammer.

Lecture IV. is devoted to the subject of the spectra of metals which are only to be observed by means of the electric arc or induction spark, and very carefully-reduced and well-executed maps of metallic spectra accompany this subject. The concluding lectures are mainly devoted to spectrum observations as applied to astronomy, and here are given many beautiful maps and chromo-litho-

graphs of solar, stellar, and nebular lines, together with terrestrial spectra for the sake of comparisons.

As we remarked above, this book is a useful addition to our scientific literature; the language is clear, and the reader is presented with a view of the subject derived from extensive Continental investigations, as well as researches which have been carried out in the United Kingdom. Indeed, Professor Roscoe's intimate acquaintance with foreign physicists occasionally leads him into the error of crediting foreign workers at the expense of his own countrymen. The book is not only valuable to men of science, but cannot fail to be also of great interest for the educated public. The recent brilliant discoveries which have been made by the spectrum into the constitution of the sun, dating from the solar eclipse of 1868, show that the prism of Newton in the hands of his successors is destined to form the basis of a method of analysis, embracing not only the solar system, but the whole material universe.

THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

MEETING AT EXETER, August, 1869.

The President's Address.

The past twelve months have been characterized by steady work rather than for many brilliant scientific results. Investigators have been rather collecting particulars than forming generalizations. The dominant scientific result of the year has been the extended knowledge which we have gained of the constitution of the sun and heavenly bodies, and this met with full recognition in the inaugural address of the President, G. G. Stokes, M.A., Sec. R.S., which was delivered in the Victoria Hall, Exeter, on the 18th of August.

After briefly alluding to the objects of the Association, the President gave some account of the most recent progress of science, selecting especially from those branches with which he was more familiar, some examples which might prove to be of pretty general interest. Amongst the various branches of physical science, Astronomy occupies in many respects a foremost rank. The science of astronomy is indebted to that of optics for the principles which regulate the construction of those optical instruments which are so essential to the astronomer. It repaid its debt by furnishing to optics a result which it is important we should keep in view in considering the nature of light. It is to astronomy that we are indebted for the first proof we obtained of the finite velocity of light, and for the first numerical determination of that enormous velocity. Astronomy, again, led, forty-four years later, to a second determination of that velocity in the remarkable phenomenon of aberration discovered by Bradley, a phenomenon presenting special points of interest in relation to the nature of light. If, in respect of these phenomena, optics received much aid from astronomy, the latter science has been indebted to the former for information which could not otherwise have been obtained. The motions and the masses of the heavenly bodies are revealed to us, more or less fully, by astronomical observations; but we could not thus become acquainted with the chemical nature of these distant objects. Yet, by the application of the spectroscope to the scrutiny of the heavenly bodies, evidence has been obtained of the existence therein of various elements known to us by the chemical examination of the materials of which our own earth is composed; and not only so, but light is thrown on the state in which matter is there existing, which, in the case of nebulæ especially, led to the formation of new ideas respecting

their constitution, and the rectification of astronomical speculations previously entertained.

We are accustomed to apply to the stars the epithet *fixed*. Defining as fixity, invariability of position as estimated with reference to the stars as a whole, and comparing the position of any individual star with those of the stars in its neighbourhood, we find that some of the stars exhibit "proper motions"—show, that is, a progressive change of angular position as seen from the earth, or rather as they would be seen from the sun, which we may take for the mean annual place of the earth. This indicates linear motion in a direction transverse to the line joining the sun with the star. But how shall we determine whether any particular star is approaching to or receding from our sun? It is clear that astronomy alone is powerless to aid us here, since such a motion would be unaccompanied by change of angular position. Here the science of optics comes to our aid in a remarkable manner. Suppose that we were in possession of a source of light capable of exciting vibrations of a definite period, corresponding, therefore, to light of a definite refrangibility. Then, if the source of light and the observer were receding from or approaching to each other with a velocity which was not insensibly small compared with the velocity of light, an appreciable lowering or elevation of refrangibility would be produced, which would be capable of detection by means of a spectroscope of high dispersive power. The velocity of light is so enormous—about 185,000 miles per second—that it can readily be imagined that any motion which we can experimentally produce in a source of light is as rest in comparison. But the earth in its orbit round the sun moves at the rate of about 18 miles per second; and in the motions of stars approaching to or receding from our sun, we might expect to meet with velocities comparable with this. The orbital velocity of the earth is, it is true, only about the one ten-thousandth part of the velocity of light. Still the effect of such a velocity on the refrangibility of light, which admits of being easily calculated, proves not to be so insensibly small as to elude all chance of detection, provided only the observations are conducted with extreme delicacy.

But what evidence can we ever obtain, even if an examination of the light of the stars should present us with rays of definite refrangibility, of the existence in those remote bodies of ponderable matter vibrating in known periods not identical with those corresponding to the refrangibilities of the definite rays which we observe? The answer to this question will involve a reference to the splendid researches of Professor Kirchhoff, which led him to make a careful comparison of the places of the dark lines of the solar spectrum with those of bright lines produced by the incandescent gas or vapour of known elements; and the coincidences were in many

cases so remarkable as to establish almost to a certainty the existence of several of the known elements in the solar atmosphere, producing by their absorbing action the dark lines coinciding with the bright lines observed. Among other elements may be mentioned in particular hydrogen, the spectrum of which, when traversed by an electric discharge, shows a bright line or band exactly coinciding with the dark line C, and another with the line F.

Now Mr. Huggins found that several of the stars show in their spectra dark lines coinciding in position with C and F, and what strengthens the belief that this coincidence, or apparent coincidence, is not merely fortuitous, but is due to a common cause, is that the two lines are found associated together, both present or both absent. And Kirchhoff's theory suggests that the common cause is the existence of hydrogen in the atmospheres of the sun and certain stars, and its exercise of an absorbing action on the light emitted from beneath.

Now by careful and repeated observations with a telescope furnished with a spectroscope of high dispersive power, Mr. Huggins found that the F line, the one selected for observation, in the spectrum of Sirius, did not exactly coincide with the corresponding bright line of a hydrogen spark, which latter agrees in position with the solar F, but was a *little* less refrangible, while preserving the same general appearance.

Assuming, then, that the small difference of refrangibility observed between the solar F and that of Sirius is due to proper motion, Mr. Huggins concludes from his measures of the minute difference of position that, at the time of the observation, Sirius was receding from the earth at the rate of 41·4 miles per second. A part of this was due to the motion of the earth in its orbit, and on deducting the orbital velocity of the earth, resolved in the direction of a line drawn from the star, there remained 24·4 miles per second as the velocity with which Sirius and our sun are mutually receding from each other.

We turn now to another recent application of spectral analysis. Various expeditions were equipped for the purpose of observing the total solar eclipse which was to happen on the 17th August, 1868, and shortly before the conclusion of the meeting of the Association at Norwich last year, the first results of the observations were made known to the meeting, through the agency of the electric telegraph. In a telegram sent by M. Janssen to the President of the Royal Society, it was announced that the spectrum of the prominences was very remarkable, showing bright lines, while that of the corona showed none. The prominences could not be clouds in the strict sense of the term, shining either by virtue of their own heat or by light reflected from below. They must consist of incandescent matter in the gaseous form. It appears from more

detailed accounts that, except in the immediate neighbourhood of the sun, the light of the prominences consisted mainly of three bright lines, of which two coincided with C and F, and the intermediate one nearly, but, as subsequent researches showed, not exactly, with D. The bright lines coinciding with C and F indicate the presence of glowing hydrogen. Several of the other lines were identified with those which would be produced by the incandescent vapour of certain other elements.

Valuable as these observations were, it is obvious that we should have had long to wait before we could have become acquainted with the usual behaviour of these objects, and their possible relation to changes which may be going on at the surface of the sun, if we had been dependent on the rare and brief phenomenon of a total solar eclipse for gathering information respecting them. But how, the question might be asked, shall we ever be able so to subdue the overpowering glare of our great luminary, and the dazzling illumination which it produces in our atmosphere when we look nearly in its direction, as to perceive objects which are comparatively so faint? Here again the science of optics comes in aid of astronomy.

When a line of light, such as a narrow slit held in front of a luminous object, is viewed through a prism, the light is ordinarily spread out into a coloured band, the length of which may be increased at pleasure by substituting two or more prisms for the single prism. As the total quantity of light is not thereby increased, it is obvious that the intensity of the light of the coloured band will go on decreasing as the length increases. Such is the case with ordinary sources of light, like the flame of a candle or the sky, which give a continuous spectrum, or one generally continuous, though interrupted by dark bands; but if the light from the source be homogeneous, consisting, that is, of light of one degree of refrangibility only, the image of the slit will be merely deviated by the prisms, not widened out into a band, and not consequently reduced in intensity by the dispersion. And if the source of light emit light of both kinds, it will be easily understood that the images of the slit corresponding to light of any definite refrangibilities which the mixture may contain will stand out, by their superior intensity, on the weaker ground of the continuous spectrum.

Preparations for observations of the kind had long been in progress in the hands of Mr. Lockyer; and on the 20th of October last year, in examining the space immediately surrounding the edge of the solar disk, he obtained evidence, by the occurrence of a bright line in the spectrum, that his slit was on the image of one of those prominences, the nature of which had so long been an enigma. Notices of this discovery were received from the author by the Royal Society on October 21st and November 3rd. These were shortly afterwards followed by a fuller paper on the same subject.

Meanwhile the same thing had been independently observed in another part of the world. After having observed the remarkable spectrum of the prominences during the total eclipse, it occurred to M. Janssen that the same method might allow the prominences to be detected at any time; and on trial he succeeded in detecting them the very day after the eclipse. Shortly after Mr. Lockyer's communication of his discovery, Mr. Huggins, who had been independently engaged in the attempt to render the prominences visible by the aid of the spectroscope, succeeded in seeing a prominence as a whole by somewhat widening the slit, and using a red glass to diminish the glare of the light admitted by the slit, the prominence being seen by means of the C line in the red.

One of the most striking results of the habitual study of these prominences is the evidence they afford of the stupendous changes which are going on in the central body of our system. Prominences, the heights of which are to be measured by thousands and tens of thousands of miles, appear and disappear in the course of some minutes; and a study of certain minute changes in the bright line F, which receive a simple and natural explanation by referring them to proper motion in the glowing gas by which that line is produced, and which we see no other way of accounting for, has led Mr. Lockyer to conclude that the gas in question is sometimes travelling with velocities comparable with that of the earth in its orbit. Moreover these exhibitions of intense action are frequently found to be intimately connected with the spots, and can hardly fail to throw light on the disputed question of their formation. Nor are chemical composition and proper motion the only physical conditions of the gas which are accessible to spectral analysis. By comparing the breadth of the bright bands (for though narrow they are not mere lines) seen in the prominences with those observed in the spectrum of hydrogen rendered incandescent under different physical conditions, Dr. Frankland and Mr. Lockyer have deduced conclusions respecting the pressure to which the gas is subject in the neighbourhood of the sun.

The President next proceeded to congratulate the Association on the successful completion of the great Southern telescope, a description of which appeared in our pages a short time ago. The telescope, constructed by Mr. Grubb, of Dublin, is now erected at Melbourne, and in the hands of Mr. Le Sueur, who has been appointed to use it. Before its shipment it was inspected in Dublin by the committee appointed by the Royal Society to consider the best mode of carrying out the object for which the vote was made by the Melbourne legislature; and the committee speak in the highest terms of its contrivance and execution. We may expect before long to get a first instalment of the results obtained by a scrutiny of the southern heavens with an instrument far more

powerful than any that has hitherto been applied to them—results which will at the same time add to our existing knowledge and redound to the honour of the colony, by whose liberality this long-cherished object has at last been effected.

The results of the deep-sea dredging committee were then briefly alluded to; but as they will be found fully described in our Chronicles and in the reports of sections of the Association, it is unnecessary to dwell upon them in this place.

The President next referred to the Faraday Memorial, and stated that the present Chancellor of the Exchequer did not think it right that the recognition of scientific merit, however eminent, should fall on the taxation of the country, though even in a pecuniary point of view the country has received so much benefit from the labours of scientific men. The carrying out of the resolution passed by the Heads of the Learned Societies being thus left to private exertion, a public meeting, presided over by H.R.H. the Prince of Wales, was held in the Royal Institution, an establishment which has the honour of being identified with Faraday's scientific career. At this meeting a committee was formed to carry out the object, and a subscription list commenced.

In Chemistry, the speaker confined his attention to three discoveries. The first was the discovery of turacine, a red colouring matter extracted from the feathers of the turaco or plaintain-eater, which has been investigated by Professor Church, who finds it to contain nearly six per cent. of copper, which cannot be distinguished by the ordinary tests, nor removed from the colouring matter without destroying it. In the turaco the existence of the red colouring matter which belongs to their normal plumage is dependent upon copper, which, obtained in minute quantities with the food, is stored up in this strange manner in the system of the animal. This example warns us against taking too utilitarian a view of the plan of creation. Here we have a chemical substance elaborated which is perfectly unique in its nature, and contains a metal, the salts of which are ordinarily regarded as poisonous to animals, and the sole purpose to which, so far as we know, it is subservient in the animal economy is one of pure decoration. The second discovery was that of artificial alizarine, the colouring matter of madder; and the third the investigations of Dr. Matthiessen on the constitution of opium bases. These discoveries have been fully referred to in our Chronicles, and it is unnecessary to repeat the details here.*

In relation to mechanism, this year is remarkable as being the centenary of the great invention of our countryman James Watt. It was in the year 1769 that he took out his patent involving the

* See 'Journal of Science,' No. xxiii., p. 427, and No. xxiv., p. 530.

invention of separate condensation, which is justly regarded as forming the birth of the steam-engine. It needs no formal celebration to remind Britons of what they owe to Watt. Of him truly it may be said "*si monumentum requiras circumspice.*"

No other physical science has been brought to such perfection as mechanics; and in mechanics we have long been familiar with the idea of the perfect generality of its laws, of their applicability to bodies organic as well as inorganic, living as well as dead. But from mechanics let us pass on to chemistry, and the case will be found by no means so clear. When chemists ceased to be content with the mere ultimate analysis of organic substances, and set themselves to study their proximate constituents, a great number of definite chemical compounds were obtained which could not be formed artificially; but as the science progressed many of these organic substances were formed artificially, in some cases from other and perfectly distinct organic substances, in other cases actually from their elements; and we may say that at the present time a considerable number of what used to be regarded as essentially natural organic substances have been formed in the laboratory. That being the case, it seems most reasonable to suppose that in the plant or animal from which those organic substances were obtained, they were formed by the play of ordinary chemical affinity; and since the boundary-line between the natural substances which have and those which have not been formed artificially, is one which, so far as we know, simply depends upon the amount of our knowledge, and is continually changing as new processes are discovered, we are led to extend the same reasoning to the various chemical substances of which organic structures are made up.

Admitting this much, Professor Stokes proceeded to ask whether the laws of chemical affinity, together with those of capillary attraction, of diffusion, and so forth, account for the formation of an organic structure, as distinguished from the elaboration of the chemical substances of which it is composed? To this he replied decidedly No! No more than the laws of motion account for the union of oxygen and hydrogen to form water, though the ponderable matter so uniting is subject to the laws of motion during the act of union just as well as before or after. In the various processes of crystallization, of precipitation, and so forth, which we witness in dead matter, there is not the faintest shadow of an approach to the formation of an organic structure, still less to the wonderful series of changes which are concerned in the growth and perpetuation of even the lowliest plant. Admitting to the full, as highly probable, though not completely demonstrated, the applicability to living beings of the laws which have been ascertained with reference to dead matter, the speaker proceeded to say that he felt constrained at the same time to admit the existence of a mysterious *something*

lying beyond—a something *sui generis*, which he regarded not as balancing and suspending the ordinary physical laws, but as working with them and through them to the attainment of a designed end.

What this *something*, which we call life, may be, is a profound mystery. We know not how many links in the chain of secondary causation may yet remain behind; we know not how few. It would be presumptuous indeed to assume in any case that we had already reached the last link, and to charge with irreverence a fellow-worker who attempted to push his investigations yet one step farther back. On the other hand, if a thick darkness enshrouds all beyond, we have no right to assume it to be impossible that we should have reached even the last link of the chain—a stage where further progress is unattainable, and we can only refer the highest law at which we stopped to the fiat of an Almighty Power. To assume the contrary as a matter of necessity, is practically to remove the First Cause of all to an infinite distance from us. The boundary, however, between what is clearly known and what is veiled in impenetrable darkness is not ordinarily thus sharply defined. Between the two there lies a misty region, in which loom the ill-discerned forms of links of the chain which are yet beyond us; but the general principle is not affected thereby. Let us fearlessly trace the dependence of link on link as far as it may be given us to trace it, but let us take heed that in thus studying second causes we forget not the First Cause, nor shut our eyes to the wonderful proofs of design, which, in the study of organized beings especially, meet us at every turn.

Truth we know must be self-consistent, nor can one truth contradict another, even though the two may have been arrived at by totally different processes: in the one case, suppose, obtained by sound scientific investigation; in the other case, taken on trust from duly authenticated witnesses. None need fear the effect of scientific inquiry carried on in an honest, truth-loving, humble spirit, which makes us no less ready frankly to avow our ignorance of what we cannot explain than to accept conclusions based on sound evidence. The slow but the sure path of induction is open to us. Let us frame hypotheses if we will: most useful are they when kept in their proper place, as stimulating inquiry. Let us seek to confront them with observation and experiment, thereby confirming or upsetting them as the result may prove; but let us beware of placing them prematurely in the rank of ascertained truths, and building further conclusions on them as if they were.

The speaker concluded his long and eloquent address in the following words:—"When from the phenomena of life we pass on to those of mind, we enter a region still more profoundly mysterious. We can readily imagine that we *may* here be dealing with phenomena altogether transcending those of mere life, in some such way as

those of life transcend, as I have endeavoured to infer, those of chemistry and molecular attractions, or as the laws of chemical affinity in their turn transcend those of mere mechanics. Science can be expected to do but little to aid us here, since the instrument of research is itself the object of investigation. It can but enlighten us as to the depth of our ignorance, and lead us to look to a higher aid for that which most nearly concerns our well-being."

Mathematical and Physical Science. (Section A.)

The meetings of this Section were opened on August 19th, by the President, Professor Sylvester, who, in his address confined himself mainly to combating the view advanced by Professor Huxley, that "mathematical training is almost purely deductive. The mathematician starts with a few simple propositions, the proof of which is so obvious that they are called self-evident, and the rest of his work consists of subtle deductions from them." And again that "mathematics is that study which knows nothing of observation, nothing of experiment, nothing of induction, nothing of causation." These statements were shown to be opposite to the facts of the case, and many instances were adduced to show that mathematical analysis is unceasingly calling forth the faculties of observation and comparison; that one of its leading features is induction; that it has frequently recourse to experimental trial and verification; and that it affords a boundless scope for the exercise of the highest efforts of imagination and invention. Rieman wrote a thesis to show that the basis of our conception of space is purely empirical, and our knowledge of its laws the result of observation; that other kinds of space might be conceived to exist, subject to laws different from those which govern the actual space in which we are immersed. Gauss called mathematics a science of the eye; and this great man was used to say that he had laid aside several questions which he had treated analytically, and hoped to apply to them geometrical methods in a future state of existence, when his conceptions of space should have become amplified and extended; for as we can conceive beings (like infinitely attenuated book-worms in an infinitely thin sheet of paper) which have only the notion of space of two dimensions, so we may imagine beings capable of realizing space of four or a greater number of dimensions.

Most, if not all, of the great ideas of modern mathematics have had their origin in observation. For instance, one gigantic outcome of modern analytical thought, itself, too, only the precursor and progenitor of a future still more heaven-reaching theory, which will comprise a complete study of the interoperation of algebraic

forms,—how did this originate? In the accidental observation by Eisenstein, some twenty years ago, of a single invariant (the quadrinvariant of a quartic), which he met with in the course of certain researches just as accidentally and unexpectedly as M. Du Chaillu might meet a gorilla in the country of the Fantees, or any one of us in London a white Polar bear escaped from the Zoological Gardens. Fortunately he pounced down upon his prey, and preserved it for the contemplation and study of future mathematicians. It occupies only part of a page in his collected posthumous works. This single result of observation (as well entitled to be so called as the discovery of globigerinæ in chalk, or of the confocal ellipsoid structure of the shells of the foraminifera), which remained infructuous in the hands of its eminent author, has served to set in motion a train of thought and propagated an impulse which have led to a complete revolution in the whole aspect of modern analysis, and will continue to be felt until mathematics are forgotten and British Associations meet no more.

The speaker continued:—"Were it not unbecoming to dilate on one's own personal experience, I could tell a story of almost romantic interest about my own latest researches (in a field where geometry, algebra, and the theory of numbers melt in a surprising manner into one another, like sunset tints, or the colours of the dying dolphin (the last still loveliest), a sketch of which has just appeared in the 'Proceedings of the London Mathematical Society,' which would very strikingly illustrate how much observation, divination, induction, experimental trial and verification, causation, too (if that means, as I suppose it must, mounting from phenomena to their reasons or causes of being), have to do with the work of the mathematician. In the face of these facts, which every analyst in this room or out of it can vouch for out of his own knowledge and personal experience, how can it be maintained in the words of Professor Huxley, who in this instance is speaking of the sciences as they are in themselves, and without any reference to scholastic discipline, that 'mathematics is that study which knows nothing of observation, nothing of induction, nothing of experiment, nothing of causation?'"

The speaker continued to say that he was not so absurd as to maintain that the habit of observation of *external nature* will be best, or at all, cultivated by the study of mathematics, at all events as that study is at present conducted, and no one could desire more earnestly than himself to see natural and experimental science introduced into our schools as a primary and indispensable branch of education; that study and mathematical culture should go on hand in hand together, and they would greatly influence each other for their mutual good. He should rejoice to see mathematics taught with that life and animation which the presence and example

of her young and buoyant sister could not fail to impart; short roads preferred to long ones; Euclid shelved or buried "deeper than did ever plummet sound;" morphology introduced into the elements of algebra; projection, correlation, motion, accepted as aids to geometry; the mind of the student quickened and elevated, and his faith awakened by early initiation into the ruling ideas of polarity, continuity, infinity, and familiarization with the doctrine of the imaginary and inconceivable. It is this living interest in the subject which is so wanting in our traditional and mediæval modes of teaching. Some people have been found to regard all mathematics after the 47th proposition of Euclid as a sort of morbid secretion, to be compared only with the mother-of-pearl generated in the deceased oyster; others find its justification, its "*raison d'être*," in its being either the torch-bearer leading the way, or the handmaiden holding up the train, of physical science; and a very clever writer, in a recent magazine article, expresses his doubts whether it is in itself a more serious pursuit or more worthy of interesting an intellectual human being than the study of chess problems or Chinese puzzles. But this is like judging of architecture from being shown some of the brick and mortar, or even a quarried stone of a public building; or of painting from the colours mixed on the palette; or of music by listening to the thin and screechy sounds produced by a bow passed haphazard over the strings of a violin. The world of ideas which it discloses or illuminates, the contemplation of divine beauty and order which it induces, the harmonious connection of its parts, the infinite hierarchy and absolute evidence of the truths with which it is concerned—these and such like are the true grounds of the title of mathematics to human regard, and would remain unimpaired were the plan of the universe unrolled like a map at our feet, and the mind of man qualified to take in the whole scheme at a glance.

At the conclusion of the above address the reading of the papers commenced. As it would be impossible to give within the limits at our command an intelligible abstract of the mathematical and some of the physical papers, we shall confine our reports to abstracts of those papers which will be of interest in their condensed form.

The first paper was the report of the Lunar Committee, read by the Secretary, Mr. W. R. Birt. Since the formation of the committee in 1864, a surface of 100 square degrees has been surveyed; the outlines of 433 objects have been laid down on a scale of 200 inches to the moon's diameter; and a catalogue has been prepared, containing notices of important phenomena bearing on the question of either transient or permanent lunar change. The report enters fully on this latter point, and, in conclusion, draws attention to certain differences between the photographs employed, particularly one with respect to a certain crater figured by Lohrmann, which is found

on De la Rue's, but not a vestige can be discovered on Rutherford's. Some attention has also been given to apparent changes of brightness and tint, a subject to which Webb called attention a few years since. Three or four somewhat conspicuous spots were adduced as exhibiting these alternations, which appear to be independent of any agencies with which we are acquainted.

Mr. W. R. Birt then read a paper "On Secular Variations of Lunar Tints." The author, in alluding to the importance of an examination of the tints of the lunar surface, remarked that to carry it out in its entirety would entail a most enormous labour, but he recommended that a few of the most prominent objects should be selected for the purpose. He called attention to the fact that changes of tint and brilliancy were common on the moon. These changes were generally referred to variations in the angle at which the sun's light fell upon the object. The author then proceeded to notice certain differences which have been observed between the tints of objects as recently determined, and those of the same objects as recorded by previous selenographers. We have the means of obtaining presumptive evidence of change of tint, independent of illumination, in the fact that if any two spots be taken, one being brighter than the other at a given epoch of illumination, should the order of brightness be reversed at any subsequent epoch, the illumination being the same, the legitimate conclusion would be that a change had occurred in the meantime; and, as being unconnected with any theoretical considerations of change, the author suggested the term "secular variation of tint" to designate such phenomena. In the concluding part of the paper the author referred to the number of spots which have been observed during the last forty-nine years on the lunar crater Plato.

In a communication "On the Lunar Crater Plato," W. R. Birt stated that certain peaks on the western wall of the crater had been measured by Beer and Maedler, the heights varying from 5000 to 7000 English feet. These peaks at sunrise cast well-defined long shadows on the floor, and these shadows had been measured by Professor Challis, of Cambridge. Mr. Birt compared delineations of the shadows by Professor Challis, the late Lord Rosse, the late Rev. W. R. Dawes, and J. Birmingham, Esq., of Millbrook Tuam, and finds some interesting results, among which may be named the proximity of the shadows of the three principal peaks to three very minute craters on the floor of Plato, thus furnishing a means of readily identifying these craters at any future time.

Mr. G. J. Symons presented the report of the committee on Underground Temperatures. The committee had tried experiments on underground temperatures at Glasgow, Dundee, and wherever they could get access to very deep wells or borings in the

earth. But the chief experiments had been tried in a well made many years ago at Kentish Town by a company formed for the purpose of supplying the district with water. The total depth in this instance was 1032 feet, 540 feet of which consisted of a bricked wall, and the remainder of a boring lined with thin sheet iron. The committee had obtained the use of the old well, and fitted up winding apparatus above it in a hut, to let specially-constructed thermometers up and down in the boring. The general result of the experiments was to prove an increase of temperature of one degree for every 52·4 feet increase in depth.

Dr. J. H. Gladstone gave an address on the Relation between the Refractive Energies and the Combining Proportions of the Metals. He pointed out that in most cases, but not all, the less the combining proportion of the metal, the greater is the refractive energy. The rule just mentioned does not hold at all with non-metallic elements, and proves most accurate with those metals which form good definite salts, such as magnesium, iron, and zinc.

Professor Gustav Magnus read a paper on the Reflection of Heat, in which he made known a discovery of his own, that fluor-spar has the property of reflecting, very largely, the dark invisible rays emitted by hot rock-salt. There is much evidence tending to prove that the heat-rays from rock-salt are of very great wave length, belonging almost to one of the extremities of the spectrum.

Lieut.-Colonel Strange, F.R.S., then spoke of the proceedings last year at Norwich, which resulted in the formation of a committee to determine whether there is adequate provision in Great Britain for the vigorous prosecution of scientific research. The committee had come unanimously to the conclusion that science had not adequate means for its vigorous prosecution. They submit, as the substance of their report, the recommendation that the full influence of the British Association for the Advancement of Science should at once be exerted to obtain the appointment of a Royal Commission to consider:—1. The character and value of existing institutions and facilities for scientific investigation, and the amount of time and money devoted to such purposes. 2. What modifications or augmentations of the means and facilities that are at present available for the maintenance and extension of science are requisite. 3. In what manner these can be best supplied.

Mr. J. P. Gassiot called attention to a curious dark deposit in certain vacuum tubes.

On Saturday the papers were almost wholly mathematical. On Monday the proceedings opened by the reading of several reports of committees. Admiral Sir E. Belcher read the report of a committee appointed to apply to the Admiralty for aid in observing

certain sea temperatures. The report pointed out that help in many cases was only offered on condition that the applicants employ clerks to search out the information required from the records, which expense the committee did not incur.

Mr. G. J. Symons read the report of the Rainfall Committee, which more especially pointed out the necessity for more stations of observation.

The report of the Tidal Committee was read by Mr. Rankine.

Mr. Glaisher read the report of the Association Committee on "Luminous Meteors." Large numbers of meteors had been seen during the past year. The report gave an account of an extraordinary meteor seen in France in October, which exploded with a detonation louder than any artillery, at, it was considered, a height of sixty miles. Much was said of the extensive observations made in America by Professor Newton and others. The report contained catalogues of all the meteors and aërolites observed. The radiant of the November meteors was well ascertained, but of the August meteors the radiant was not certain.

Dr. Neumayer read an abstract of a paper detailing the facts relating to the fall of a meteor a short time ago at Krähenberg. The fall took place in the day-time, and so great was the velocity of the mass that it buried itself two feet deep in the sandstone rock. It was dug out while still warm, and found to weigh 31½ lbs. The sound was heard over a radius of thirteen miles.

Mr. Glaisher narrated the results of some meteorological experiments made in the car of the captive balloon. The principal fact was, that often when the air near the ground is quite still, and the smoke from the chimneys of the houses rising vertically, a hard gale is blowing aloft, and that at a height of less than 1000 feet.

The most important paper read on Monday was one by Mr. Whitworth, "On the Penetration of Armour-Plates by Shells with Heavy Bursting Charges fired obliquely," in which he set forth the superiority of the flat projectile over the pointed one for piercing armour-plated ships.

M. Janssen then described in French his method of obtaining views of the solar prominences at any time by means of a rapidly revolving slit and spectroscope.

A paper by Professor A. Morren, "On the Chemical Reaction of Light," discovered by Professor Tyndall, was then read. Professor Morren said that he had repeated Dr. Tyndall's celebrated experiments on the action of light upon vapours in tubes, but that, living in the south of France, he used the rays of the sun, instead of the light from the electric lamp. His tubes, like those of

Dr. Tyndall, were of glass, with flat glass ends, and glass stopcocks. After exhausting the : r from the tube, he permitted a mixture of absolutely pure dry ydrogen and nitrogen gas to enter, and on passing a cone of sunlig t from a lens through the long axis of the tube, he was surprised to see a cloud forming, because of chemical decomposition set ı). This led him to question the method employed to dry the gases, which was by passing them through powdered glass wetted with sulphuric acid. When chloride of calcium and other methods of drying gases were tried, no clouds were formed by the sunlight, so at last he came to the conclusion that a source of error lay in a trace of sulphurous acid gas, taken up by the hydrogen and the nitrogen from the sulphuric acid. The latter acid employed by him was absolutely pure, and contained no trace of arsenic from the use of impure sulphur in its manufacture. In the remainder of his paper he explained the exact nature of the chemical reactions which took place in his tube, which reactions he, like Dr. Tyndall, ascribed to a motion of separation set up between the atoms of each molecule, by the short blue and violet waves of the solar spectrum.

Mr. W. Huggins, F.R.S., read a paper "On the Heat of the Stars." The instruments used were a telescope, a very sensitive thermopile, and a galvanometer, by means of which faint indications of heat were obtained, accompanying the light from different stars.

Dr. Balfour Stewart F.R.S., read a paper on a very cleverly designed "New Rain Gauge," invented, made, and tested by Mr. Beckley, of Kew Observatory.

Chemical Science. (Section B.)

The proceedings in this Section were opened by an address by the President, Dr. Debus, in which he reviewed the various directions in which chemical science was progressing, and directed attention to some of the fundamental ideas which guide chemists in their researches. The address was listened to with great attention, but is too technical to admit of more than this brief allusion to it. Most of the papers and reports communicated to this Section were on subjects of special more than general interest, and will not bear condensation. We will therefore select a few only of the papers which treat upon matters likely to be of general interest to our readers.

Dr. Jacobi read a paper on the "Electro Deposit of Iron," illustrating his remarks by a series of plates of extreme beauty. The solution from which the metallic iron was deposited consisted of a double sulphate of iron and magnesia. It was found desirable

to coat the recipient of the deposit with a thin film of nickel or copper.

The Committee on the Chemical Nature of Cast Iron reported that they entrusted the preparation of pure iron to Mr. Matthiessen, who expressed a hope that next year a great deal of very useful information will be obtained on the chemical nature and physical properties of pure iron and its alloys. Prof. Matthiessen then detailed very elaborately the nature and properties of pure iron, and the best methods for its preparation and fusion.

Professor Calvert, in some remarks upon the series of experiments conducted by him into the nature and condition of rust, stated that he thought the oxidation of the bottom of iron ships might be prevented by an external coating of an alloy of lead and antimony, and by placing an alkali in the bilge-water within the

Professor Tomlinson read a paper on the supposed Action of Light on Combustion. From a series of experiments upon candles of different sizes and weights in dark chambers and day and sun light, it was found that the increase of temperature alone led to increase of consumption of material; the final conclusion being that the direct light of the sun, or the diffused light of day, has no action on the rate of burning, or in retarding the combustion of an ordinary candle.

Mr. Walter Weldon read a long paper "On the Manufacture of Chlorine by means of perpetually regenerated Manganite of Calcium." What has hitherto been the ordinary process of manufacturing chlorine, consists in digesting ores containing peroxide of manganese with hydrochloric acid. The chloride of manganese, which is a residual product of this process, has hitherto been ordinarily thrown away. Mr. Weldon decomposes this chloride of manganese by lime, and then blows air through the resulting mixture. The protoxide of manganese absorbs oxygen from the injected air, thereby becoming converted into peroxide, which combines with the equivalent of lime used in excess, forming therewith the compound which the author calls manganite of calcium. The compound thus produced is employed instead of manganese ores for the liberation of chlorine from hydrochloric acid, and is then reproduced from the resulting solution of chloride of manganese, and so on continually, the same manganese being thus employed over and over again perpetually. Last year there were made in this country, and on the Continent, about 120,000 tons of bleaching-powder, and this bleaching-powder costs on an average about 5*l.* per ton for native oxide of manganese. Mr. Weldon's process produces bleaching-powder at a cost of only 15*s.* per ton for

manganite of calcium, and enables more chlorine to be obtained from a given quantity of hydrochloric acid than has hitherto been usually obtained therefrom.

Mr. Sorby sent a short note on Jargonia, in which he stated that zirconia was white, but that after ignition jargonia is of a clear straw-colour, paler than that of tungstic acid, but deeper than that of ceroso-ceric oxide.

Dr. Andrews read a short paper "On the Absorption Bands of Bile." A solution of bile in water or alcohol exhibits in the stereoscope well-marked absorption bands, which may be used as a characteristic test for the presence of bile, and even as a means of estimating approximately its amount in urine or other liquids having no absorption bands of their own.

Professor Janssen then delivered in French a discourse "On the Approximate Estimation of Sodium by Spectrum Analysis," which was followed by a discourse on the absorption of the rays of the spectrum by the vapour of water. Both these papers were copiously illustrated on the black board.

Mr. Spence then read a paper "On the Production of Higher Temperature by Steam of 212° Fahrenheit," and showed by experiment that the steam of boiling water at 212°, passing through a saturated solution of nitrate of soda, raised the temperature to 238°.

An interesting paper by Dr. Fritsche, a Russian chemist, "On the Structural Change in Block Tin," was read by Mr. Roberts, of Her Majesty's Mint. Dr. Fritsche found that the intense cold of St. Petersburg, during the winter of 1867, caused solid blocks of tin to crumble and fall into pieces. That the change was due to intense cold was proved by submitting blocks of tin to a temperature of $-40°$ C., when the same structure was induced.

Our space will not enable us to do more than allude to several important papers on Water Supply and Utilization of Sewage, which were communicated by Dr. Paul, E. C. C. Stanford, and H. Bamber, and which are referred to at greater length in our report of Section G (Mechanical Science).

Geology. (Section C.)

Professor R. Harkness, F.R.S., the President of this Section, adopted for the subject of his opening address the Geology of Devonshire. He first spoke of the Pilton beds, which form the link between the Devonian and Carboniferous series, so well seen in this county, and which have been so ably investigated by Murchison and Sedgwick, Godwin-Austen, De la Beche, Lonsdale, Phillips,

&c., &c., &c. He pointed out their relation to certain beds in the south-west of Ireland, which were believed to occur in the same horizon as the Pilton shales. In referring to the labours of the Irish Geological Survey, the President paid a graceful tribute to the memory of Professor J. Beete Jukes, F.R.S., its late Director, whose active life has terminated since the publication of our last number. Among the latest labours of Mr. Jukes was the publication of a series of papers "On the Carboniferous Slate (or Devonian Rocks) and the Old Red Sandstone of South Ireland and North Devon;" "On North Devon and West Somerset," and "South Devon and Cornwall." There is reason to apprehend that the additional effort needed to carry out these and other extra-official scientific labours did much to curtail the life of one who was beloved by all who knew him, and whose loss we must all deeply regret.

Taking the Irish localities first, the President contrasted the Wexford district, with its 200 feet of Old Red Sandstones resting conformably on Cambrian strata, with Hook Point, Comeragh, Dungarvon, West County Cork, as far south-west as Glengariff and Killarney, where the unfossiliferous "Glengariff Grits" attain a thickness of 10,000 feet. Of all this vast thickness of sedimentary deposits, included in the Old Red Sandstone series in Ireland, only a thin band of Yellow Sandstones is fossiliferous, having yielded plants, mollusca, crustacea, and fishes.

This band (which is elsewhere reported upon by Mr. W. H. Baily) occurs at Kiltorcan, co. Kilkenny.

Professor Harkness also showed the change which the Lower Limestone shales or Carboniferous slates undergo in passing south-westward from Hook Point, where their thickness is inconsiderable, to Cork Harbour and Kinsale, where they are 6500 feet in thickness, and where gritty beds make their appearance, which in Coomhola Glen attain a thickness of 3000 feet. These "Coomhola Grits" contain some peculiar fossils, and have others also common to the Carboniferous slates.

Returning to Devonshire, the President pointed out that to the north-east of Baggy Point hard purple sandstones occur (= to the Old Red Sandstones), overlain in North Devon by light-coloured beds, the equivalents of the "Yellow Sandstones" of Ireland; that above these again, at Marwood, were greenish-grey grits, with plant-remains (*Filicites linearis* and *Sagenaria Veltheimiana*), such as the base of the Carboniferous slates afford, these being identified with the "Coomhola Grits;" higher still, the Pilton beds had yielded fossils common also to the Carboniferous slates. He called attention to a common misapprehension existing among English geologists that the "Coomhola Grits" are *below* the base of the Carboniferous series, whereas they are truly a part of the Carboniferous slates.

He believed the difficulty of correlating the two areas arose

from the fact that the boundary line between the Devonian or Old Red Sandstones and the Carboniferous series had been placed in two different horizons. In Ireland the Carboniferous slates and interbedded "Coomhola Grits" form the base of the Carboniferous series; in England they are treated as belonging to the Devonian.

Professor Harkness then alluded to the Triassic pebble-bed at Budleigh Salterton, with its remnants of palæozoic fossils. He mentioned the recent discovery by Mr. Whitaker of reptilian remains, referred by Professor Huxley to *Hyperodapedon*. He drew attention to the Miocene Lignite beds of Bovey Tracey, the Flora of which has been so ably described by Dr. Oswald Heer, and the geology by Mr. Pengelly. Dr. Heer has identified many forms of plants with those which occur in the Miocene beds of Arctic America, Greenland, and Spitzbergen.

In referring to the exploration of Kent's Hole and similar ossiferous caverns, the President observed that geology and archæology were now shading into each other, and although the early history of mankind had long remained dim and indistinct like distant land, we were, by the labours of Lyell, Lubbock, and others, acquiring a clearer conception of early man, his mode of life and conditions of existence.

Mr. Godwin-Austen's paper "On the Devonian Group Considered Geologically and Geographically," dealt with the probable distribution of land and water during the Devonian epoch, and the effect of such conditions on the Fauna and Flora of the period. He spoke of the wide extent of the Devonian formation in Europe, Asia and America, and of the old Silurian land-surface which existed in the latter country during its deposition. From the fact that the fossil fishes of the Devonian belonged to the Ganoid family, the author inferred that a large portion of these beds were of lacustrine (fresh-water) origin; at the same time he admitted that vast marine accumulations were also simultaneously in process of formation in the adjoining seas. He spoke of the passage of the Old Red Sandstone group into the Silurian at its base, and into the Carboniferous series above, and concluded by indicating its easterly extension across Europe.

Dr. P. Martin Duncan presented his "Second Report on British Fossil Corals." After describing several new forms and referring to the 140 species already published, the author stated that 251 species of corals had been met with in British Secondary and Tertiary strata.

The author showed that not only are we able by the presence of certain corals to arrive at a correct estimate of the conditions of the seas of by-gone epochs, but also to trace out the ancient coast-lines by their coral reefs.

Mr. James Thomson exhibited the results of his labours in preparing sections of Carboniferous Limestone Corals, which, after being mounted on glass, have been photographed most successfully, so as to exhibit the most minute points of their structure.

Mr. G. W. Ormerod described the Granites of the northerly and easterly sides of Dartmoor. He mentioned that Schorl and Tourmaline are of frequent occurrence in these granites, but whether they were all of one age he was uncertain; the "elvans" or veins crossing the mass were undoubtedly of later age. Mr. Ormerod had not discovered any glacial striæ; but Dr. Otto Torell had examined the gravel near Hunt's Tor, and had declared it to be a true glacial moraine.

Mr. W. Pengelly, in a note on the "Source of the Miocene Clays of Bovey Tracey," showed that they were mostly formed of disintegrated granite, interstratified with the lignite beds.

Mr. T. Davidson's paper on "The Brachiopoda hitherto obtained from the 'Pebble-bed' of Budleigh Salterton," showed that the pebbles were a mixture of Devonian and Silurian strata, ten species belonging to each formation, and fifteen being new and undescribed forms. The fossil contents of the pebbles pointed to Normandy as the locality whence they had originally been derived.

Mr. Edward Hull traced the source of the Quartzose Conglomerates of the New Red Sandstone of central England (which in Lancashire and Cheshire attained the thickness of 700 feet) to the Old Red Sandstone formation. The pebbles were all liver-coloured quartzites, well rounded and water-worn, never subangular. The author considered they had gone through at least two periods of trituration. An examination of the Old Red Conglomerates near Loch Lomond fully confirmed his view as to their origin.

Mr. Henry Woodward gave an account of the Fresh-water Deposits of the Valley of the Lea in Essex, exposed in excavating the East London Waterworks Company's new reservoirs at Walthamstow. The excavations cover an area of 120 acres, and the materials removed are all of Post-Tertiary age, consisting of sand, clay, loam, peat, shell-marl, and river gravel. Twenty-six species of shells were identified, all of living species. The osseous remains include man, the wolf, fox, beaver, horse, wild boar, red deer, roebuck, fallow deer, reindeer, the elk, the goat, three species of oxen (*Bos primigenius*, *B. longifrons*, and *B. frontosus*), the sea-eagle, and some bones of fishes. In the deep trenches of the "puddle-walls" were found tusks of the mammoth and horns of the gigantic ox and deer. The presence of the reindeer, the elk, and the beaver, in so modern a deposit and so near to London is full of interest.

Mr. Pengelly presented the "Fifth Report of the Committee on the Exploration of Kent's Cavern." He stated that in the layer of black soil beneath the floor of the "vestibule" 366 flint implements had been obtained, together with flint cores, a bone needle, a bone harpoon or fish-spear, serrated on one side. Altogether 3948 boxes of bone fragments had been taken out, which Professor Boyd Dawkins had undertaken to examine. In the breccia beneath the cave-earth a flint flake had been discovered, associated with remains of the cave-lion, cave-bear, and mammoth.

Professor Boyd Dawkins gave some account of the animals. He stated that the men who lived in the cave when the black layer was being deposited were cannibals, split and gnawed human bones having been met with. He had identified in the lower layer bones of the glutton, the tailless hare, the beaver, &c.

Mr. H. H. Howorth communicated a very elaborate essay on "The Extinction of the Mammoth," in which he had collated all the statements respecting that animal to be found in the various works on Siberia, &c. He concluded that climatal conditions had extinguished the mammoth, and not the men of the Stone age.

Mr. Pengelly gave a short notice on the alleged occurrence of *Hippopotamus major* and *Machairodus latidens* in Kent's Hole. He showed good evidence of the latter animal's presence, but stated that the former had never been met with in this cavern.

Mr. W. H. Baily read the "Report of the Committee for the Exploration of the Devonian Beds of Kiltorcan, co. Kilkenny." A new fossil fern (*Adiantites*), a *Sagenaria* in fructification, and a new Limuloid Crustacean, were the most noteworthy results of this investigation, which we are glad to state is to be continued.

Mr. Charles Moore called attention to the occurrence of remains of *Teleosaurus* in the nodules of the Upper Lias at Ilminster.

Mr. George Maw's paper "On the Trappean Conglomerates of Middletown Hill, Montgomeryshire," furnished an excellent account of the Trap-rocks of Lower Silurian age which form this ridge, running parallel with the Breidden Hills on the borders of Shropshire and Montgomeryshire. Great beds of bouldered trap occur, composed of boulders of compact felstone imbedded in a matrix of felstone tuff. The interbedded traps are bounded on either side by Lower Llandeilo flags, and are collectively about 780 feet in thickness. Other eruptive beds were also noticed in this hill. The author suggested that the porphyritic greenstone of the Breidden Hills was probably emitted from the same point of eruption as these bedded traps. The local association of intrusive greenstones with interbedded felstones of Lower Silurian age, was stated to be very general in North Wales.

Mr. James Thomson's paper "On the Teeth and Dermal Structure of *Ctenacanthus* and on New Forms of *Pteroplax* and other Carboniferous Labyrinthodonts, and of *Megalichthys*," was intended to prove that several so-called genera founded upon fossil fishes' teeth, were in reality only dermal spines. Mr. Thomson also showed that three or four existing genera could now be united in one. He exhibited a fine suite of Labyrinthodont and fish-remains, which he stated Professor Dr. Young would shortly describe.

Mr. W. Carruthers called attention to the occurrence of Reptilian eggs in the Stonesfield slate and in the Greensand of the Isle of Wight. They were forwarded to him as fossil fruits, and had a peculiarly glossy appearance, and the test was very thin.

Mr. Henry Woodward noticed (1) the occurrence of a new form of *Stylonurus* from the Cornstones of Herefordshire, and (2) the discovery of a large Myriapod (*Euphoberia Brownii*) in the Coal-measures of Kilmaurs, near Glasgow.

Mr. J. Randall's paper "On the Denudation of the Shropshire and Staffordshire Coal-fields," treated of the mineral character of some of the coal-seams, and also showed how several of them had been cut off by denudation. The author believed these fields were once continuous, but that they had been separated by denudation.

Dr. C. Le Neve Foster communicated a note on the occurrence of the mineral Scheelite at Val Toppa Gold Mine, near Domodossola, Piedmont. It is found associated with quartz, iron-pyrites, zinc-blende, calc-spar, brown-spar, and native gold. Scheelite (or tungstate of lime) is called "marmor-rosso" in Piedmont, and is looked upon as a good indication of the presence of gold.

Mr. John E. Taylor noticed certain phenomena in the Drift near Norwich. The contorted, furrowed, and displaced condition of the Boulder-clay and Drift beds, and the fractured and dislocated appearance of the Chalk along these lines of disturbance, could best, Mr. Taylor suggested, be explained by the action of icebergs. A paper "On the Water-bearing Strata in the Neighbourhood of Norwich," by the same author, followed. It dealt with the origin of "sand-pipes" in the Chalk, and their action as natural drains, and the author gave an interesting statement of the effect of steam-power pumping in lowering the level of the wells around.

Mr. G. A. Lebour offered some Notes on the Denudation of Western Brittany, and on the Granites of Lower Brittany.

Dr. H. A. Nicholson contributed an account of some new forms of Graptolites from the Lower Silurian series.

Mr. Charles Moore's "Report on the Investigation of Veins containing Organic Remains which occur in the Mountain Limestone

of the Mendips and elsewhere," showed that these fissures must have remained open from a very early period, as they were found to contain Liassic and Carboniferous fossils, together with teeth of fishes. Mr. Moore had also discovered land and fresh-water shells, seeds of *Flemingites*, and large numbers of *Foraminifera* and *Entomostraca*. He considered that these discoveries must lead to an entirely new theory to explain mineral veins, as neither segregation nor thermal action could be reconciled with the presence of organic life in these fissures.

Mr. H. B. Brady noticed the *Foraminifera* discovered by Mr. Charles Moore, and especially referred to *Involutina*. The three genera mentioned by him were all still existing.

Mr. C. W. Peach recorded the discovery of *Orthoceratites*, Corals, &c., in the rocks between Nare Head and Porthalla Cove. This is the nearest point to the Land's End where Devonian fossils have yet been met with.

Mr. H. Bauerman, in reporting on Ice as an agent to produce Geological change, gave instances of the grooving power of ice as well as its ability to transport blocks and to form moraines. He thought that it would be necessary to obtain international scientific co-operation before accurate data could be brought together.

Mr. R. Brown adduced evidence to show that the west coast of Greenland was subsiding, and that points along the eastern coast had been elevated.

Mr. George Maw recorded the occurrence of insect-remains and fresh-water shells from the Lower Bagshot Leaf-bed of Studland Bay, Dorsetshire, not heretofore observed.

Dr. Henry Hicks gave an account of the discovery of Fossil Plants (?) in the Cambrian Rocks, near St. David's. In these Upper Longmynd rocks Dr. Hicks has met with many new species of Trilobites 1500 feet below the horizon at which organic remains had hitherto been found. He had also detected plant-remains, but they were doubtfully referred to plants, and were considered to be the tracks of Annelids and Trilobites by Professor Phillips and Mr. Etheridge. The importance of Dr. Hicks's discoveries is nevertheless very great, and we cannot but deeply regret that he has, by death, been deprived of the valuable co-operation of Mr. J. W. Salter (our highest authority on palæozoic fossils) in carrying on these researches.

Dr. Mann gave a description of the Gold country of Natal, and the localities where the precious metal had been met with.

Mr. W. Stephen Mitchell presented the "Report of the Committee

for investigating the Leaf-beds of the Lower Bagshot series of the Hampshire Basin." Of the Alum Bay plants, Mr. Mitchell observed that the forms so abundant on the mainland were wanting here. *Aralias, Dryandras, Cussonias, Dalbergias,* &c., had turned up in great abundance, as well as Cinnamon plants. Although the last-named leaves appear to agree with some of the *Smilaceæ*, he was fully convinced that they were true Cinnamons. The beds of Whitecliff Bay give promise of a still richer harvest. Specimens have also been obtained near Corfe. An accurate survey of these beds is being prepared to ascertain the relative levels of the Alum Bay and Mainland beds, under the superintendence of Mr. Mitchell.

Mr. Robert Etheridge described the occurrence of a large deposit of Terra-cotta Clay at Watcombe, Torquay. The clay, which is almost identical with that of Etruria, occupies a depression in the New Red Sandstone, which the author believed to have been a fresh-water lake wherein the deposit was accumulated. The clay is remarkable for its fine subdivision, and is of excellent quality for the production of fictile wares. It contains more than 60 per cent. of silica, 20 per cent of alumina, and 7 per cent. of peroxide of iron, also soda and potash salts.

Mr. J. Logan Lobley presented a very elaborate paper "On the Distribution of the British Fossil *Lamellibranchiata,*" containing the results of a careful compilation of all the described species of fossil *Conchifera* in Great Britain, which, when printed *in extenso*, will furnish important Tables for the palæontologist and geologist.

Professor James Tennant gave an account of the Diamonds received from the Cape during the past year, the largest of which weighed 83½ carats.

Mr. John Edward Lee called attention to some remarkable Glacial Striæ exposed at Portmadoc, in North Wales. These glaciated surfaces are by no means uncommon in Wales, but are frequently concealed beneath beds of drift. The present glaciated surface is very fine, but is being rapidly quarried away.

Biology. (Section D.)

When the Committee of this Section met on Wednesday the 18th, irrepressible Anthropology again led to a warm and somewhat personal discussion. A separate department of Physiology was proposed, and acceded to; but when Dr. Hunt* proposed that a department of Anthropology should also be formed, an objection

* Before the close of the meeting, Dr. Hunt left Exeter seriously ill, and it is with great regret we hear that he died a few days afterwards.

was made that there were not papers enough, and it was determined "that there be no department of Anthropology." Dr. Hunt then demanded that the papers which he had given in to be read before the department of Anthropology should be returned to him, but it was decided that they could be given up only on the personal application of the several authors. It was finally arranged that Monday, and if necessary Wednesday, be devoted to papers on Ethnology and Anthropology, and that the chief department of the Section have its title changed to "Zoology, Botany, and Ethnology." These arrangements were not however carried out, for on Tuesday and Wednesday Ethnological and Anthropological papers were read in a separate room, although the name of a "department" had been refused.

In the department of Zoology and Botany Mr. Spence Bate presided, and delivered a very interesting address "On the Physical Peculiarities of Devonshire and Cornwall." He alluded chiefly to the distribution of animals and plants; to the extreme mildness and uniformity of the climate; and to the interesting archæology of the district. The south-western peninsula was beyond the range of the nightingale; the glowworm might be seen shining in December; and strawberries were often gathered at Christmas. On the wastes of Dartmoor and the uncultivated lands of Cornwall stood many an unrecorded monument of antiquity. Year by year they were gradually passing away, and it appeared to him to be the duty of Ethnologists to explore all those which had not yet been accurately studied, and to take such steps as were necessary to preserve them all from destruction.

The business commenced with the "Report of the Committee on a Close-time for Birds," which was read by Mr. H. E. Dresser, and was followed by a paper by Rev. H. B. Tristram, "On the Effects of Legislation on the Extinction of Animals." The Report stated that the recent Act for the Preservation of Sea-fowl was a first step, and that it was advisable that it should be followed by legislation establishing a "close-time" for all birds (with a few special exceptions), as was the case in many countries of Europe and America. Mr. Tristram showed the effects of legislation, or the want of legislation, in causing the extinction of many animals. He argued that if man did not interfere, a balance would be established by nature which would be the best for all parties, and that by destroying birds and other animals considered to be noxious, man almost invariably produced greater evils than those which he tried to obviate. As an example, he might mention that the persistent raid of the gamekeepers against all birds of prey had led to such an increase of wood-pigeons in some parts of the country, that they caused a serious injury to the farmer by consuming large quantities

of grain. The sparrow-hawk was the only bird which could capture a wood-pigeon on the wing, and the gamekeepers destroyed this as well as kites and buzzards.

An animated discussion took place on both these papers. Professor Huxley strongly opposed all protective legislation, except in the one case of the salmon fishery, which he said was exceptional, because by placing nets across a river you could catch every salmon that was in it, and so exterminate them; but that this could not be done in the case of any other animal. He ridiculed the idea of the House of Commons adding to its other duties the protection of the whole British fauna and flora, about which it was so utterly ignorant; and believed that their tinkering could only lead to evil results. Sir John Lubbock, on the other hand, advocated such legislation, which he thought was both safe and useful, and thought that, considering the immense increase of our population and the extension of our towns and manufactures, we ought to do what we could to prevent the wilful and purposeless extermination by man of that variety of living things which added so much to the beauty and interest of our country. Mr. Wallace made some remarks on the accurate balance of the powers of offence and defence in nature, which led to all diseased or less perfectly organized creatures dying or being killed off, and to that appearance of perfect health and symmetry in all wild creatures, which was one of their charms as contrasted with domesticated animals. When man interfered with this balance, either by protection or extermination, imperfection and disease appeared and rapidly spread; and he quite agreed with Mr. Tristram that the grouse disease would probably have been stamped out on its first appearance, had not the sanatory police of nature, the birds of prey, been so greatly reduced by man. Drs. Hooker and Scott and Messrs. Hanbury, Newton, Norman, Dalrymple, E. Bowring, and Miss Becker, also took part in the discussion.

Mr. Hallett, the producer of the celebrated "pedigree wheat," read a paper "On the Law of the Development of Cereals;" in which he stated that, after twenty years of observation and experiment, he had arrived at the conclusion that every fully developed plant of wheat, oats, or barley presents one ear finer than all the rest, and in that ear one grain superior in productive power to all the rest. This superiority is transmissible, and thus we at last arrive at and maintain a grain of the best quality and highest productive powers.

Some Botanical papers of less general interest were afterwards read.

On Friday the entire Section met in one room to hear papers of general interest. Dr. Dickson first exhibited some abnormal

Primulas, in which the style and stamens were either both long or both short—a fact difficult to account for on the theory of reversion, as both could not be the original form.

The Rev. A. M. Norman then read an account of the recent successful dredgings in the 'Porcupine,' in a letter from Professor Wyville Thomson, prefacing it with a sketch of what had been already done in deep-sea dredging. In the first excursion this season Mr. Gwyn Jeffreys had dredged in 1472 fathoms; but Professor Wyville Thomson, finding the weather very fine, proceeded to the deep water off the Bay of Biscay, and succeeded in bringing up $1\frac{1}{2}$ cwt. of ooze from the enormous depth of 2435 fathoms, with a bottom temperature of 36°·5 Fahr. Subsequently, at 2090 fathoms, 2 cwt. of chalk-mud was brought up. These dredgings contained a fine *Dentalium* and other mollusca, crustaceans, annelids, crinoids, and starfishes, demonstrating the existence of all the higher forms of marine life in the deep abysses of the ocean. The dredge was down three hours. From careful temperature observations it was found that the effects of solar heat did not reach farther than 20 fathoms, while some other extraneous source of heat, probably that of the Gulf-stream, was detected as far as 500 to 700 fathoms; after that the temperature decreased 0°·2 for each 200 fathoms, which was probably its normal rate. The deep water was analyzed, and found to contain an excess of oxygen and of organic matter, thus explaining the source whence the living jelly of the ooze, *Bathybius*, derived its nourishment.

In from 500 to 700 fathoms water *Cidaris* was abundant, as well as vitreous sponges in great variety and of many new types, and organisms allied to Ventriculites, thus exhibiting a series of forms strikingly similar to those characteristic of the true Chalk formation. As this chalky ooze was now known to extend over the bed of all the great oceans, it was a fair presumption that this peculiar substance had been forming continuously, somewhere or other, from the Cretaceous epoch to the present day; and as many of the characteristic forms of the chalk (although of distinct species) were proved to be still in existence, it was very possible that some of the chalk deposits of the globe might be of various intermediate ages between the Cretaceous and recent epochs.

Professor Huxley, Dr. Hooker, and Dr. Percival Wright took part in the discussion, the former adverting to the immense interest of the discovery that the direct descendants of chalk fossils were now in existence almost unchanged; and Dr. Hooker claiming that Captain Ross's Antarctic dredgings had first demonstrated the variety and abundance of deep-sea life, and had disproved Edward Forbes' celebrated theory even before it had appeared.

The greater part of Friday was occupied by Archdeacon Freeman, Rev. F. O. Morris, and Dr. McCann, who read papers opposed to Darwinianism and Evolutionism. The Archdeacon's paper was simply a sermon, treating every statement in the Mosaical account of the Creation as a fact of equal value with the facts observed by naturalists, and dwelling mainly on "those mysterious four-footed creatures, the cherubim," which it was maintained were the antitypes of all created things. Mr. Morris brought forward the usual old objections to Mr. Darwin's views, such as the assertion that varieties only last so long as artificial culture is continued; and the supposed inextricable dilemma that immigrants into a new country must be either adapted or not adapted to their new conditions; if adapted, why should they change? if not adapted, how could they exist till they changed? Dr. McCann's paper was a vigorous and able attack on Professor Huxley's celebrated article "On the Physical Basis of Life," which, as it will no doubt be published in full, it is unnecessary to say more about here than that it contained some very hard and telling hits at the weak points in the Professor's philosophy. Great interest was manifested in Professor Huxley's reply, which consisted, however, more of sarcasm than of argument. Dr. Hooker, Messrs. Vivian, Wallace, and others also spoke, and much surprise was expressed that the time of the Section should have been occupied by papers which ought never to have been admitted, since they either transgressed the limits of scientific inquiry or contained nothing original.

When the Section again descended to the level of Natural History science, Professor E. Percival Wright described a new shark of a monstrous size, which he had discovered at the Seychelle Islands, and which he named *Rhinodon typicus*. He saw specimens which he computed to be sixty feet long, although he could only obtain smaller ones for examination, and these appeared to subsist entirely upon sea-weed.

Miss Lydia Becker read a paper "On Alteration in the Structure of *Lychnis diurna* observed in connection with the Development of a Parasitic Fungus." This was a curious case of the occurrence of bisexual plants of which the anthers were attacked by a fungus which gave them a purple colour; this fungus only attacking the hermaphrodite and not the male plants, Miss Becker supposed that the fungus was the cause of the development of the pistil in what would otherwise have been unisexual male plants. Professor Balfour and Drs. Dixon and Wilks took part in the discussion, and while they all admitted the value and interest of Miss Becker's observations, did not agree with her interpretation of the facts. They could not, however, offer any more satisfactory expla-

nation of the phenomena, and waited for further observations to clear up the difficulty.

Mr. T. Blandford read a paper "On the relations of the Fauna of British India to that of the Ethiopian and so-called Indian Regions." He showed that the Indian peninsula could be divided into several districts characterized by the predominance of African, Malayan, or purely Indian types.

Mr. W. F. Webb gave his "Five Years' Experience of Artificial Fish-breeding, showing in what waters Trout will and will not thrive." He believed it was a question of the temperature of the water, which required to be cool and equable.

Mr. Frank Buckland then gave an account of "The Salmon Rivers of Devon and Cornwall," in his usual humorous and impressive style, offering many suggestions for their improvement by purification, clearing away obstructions, forming spawning beds, and by artificial hatching.

Mr. Antonio Brady exhibited some specimens of Gum Anime from Zanzibar, containing insects and a lizard. It was found in sandy deposits where there are now no trees, and is probably of high antiquity.

Mr. Spence Bate read an elaborate report "On the Marine Fauna and Flora of the South Coast of Devon and Cornwall," describing the new and rare species which have been recently obtained.

Other papers read were, "On a Variety or Hybrid of *Perdix cinerea*," by Dr. Scott; "On Initial Life—Infusoria," by Mr. C. S. Wake; "On the Remains of a Whale washed ashore at Babbicombe, South Devon," by Mr. Pengelly; "On the Mammalian Fauna of North-West America," by Mr. Robert Brown, F.R.G.S.; "On the Land and Fresh-water Shells of Nicaragua," by Mr. Ralph Tate, F.G.S.; and "On some curious Fossil Fungi from the Black Shale of the Northumberland Coal-fields," by A. Hancock, F.L.S., and Thomas Atthey.

In the department of Anatomy and Physiology, Mr. Busk presided. The first paper was Dr. Richardson's Report "On the Physiological Action of the Methyl Series," a subject whose chief interest was medical.

Mr. E. Ray Lankester read a report "On the Spectroscopic Examination of Animal Substances." He first explained the methods of studying absorption spectra, and the value of the evidence they afforded in physiological research. He then discussed the distribution of Hæmoglobin (the red oxygen-condensing matter of the blood corpuscles) in the animal kingdom, showing it to be

present in certain Molluscs, aquatic insect larvæ, a Phyllopodous Crustacean, many Annelids, and in all Vertebrata, as well as in the muscles of Mammals, Birds, and Fishes. The action of reagents on Hæmoglobin was then described, and the various derivative spectra obtained by other observers were compared, and their place in the spectrum scale fixed. Chlorocruorin, the green blood-stuff discovered by Mr. Lankester in *Siphonostoma* and *Sabella*, and Chondriochlor, the chlorophyl-like body obtained from *Spongilla fluviatilis*, were also fully described.

Dr. Wilson's paper "On the Moral Imbecility of Habitual Criminals," exemplified by Cranial Measurements, attracted a considerable audience. The author maintained that the majority of such criminals were devoid of all moral sense and principle, and could rarely distinguish between right and wrong. They exhibited a tendency to revert to the types of the uncivilized races, and cranial deficiency was associated with real physical deterioration. The habitual criminal was the victim of inherited proclivities to which he must yield, and of a course of training which had so warped his nature that he was incapable of appreciating any code of morality which did not harmonize with his own vicious tendencies. Dr. Wilson had examined and measured about 460 heads, and had arrived at the conclusion that habitual criminals were cranially deficient, especially in the anterior lobes of the cerebral portion of the brain.

The Rev. W. Caine, chaplain of the county gaol of Manchester, maintained that ignorance and defective intellect was by no means a universal or even general characteristic of criminals; and he startled the meeting by the statement that at one time, out of 700 Protestant criminals in the gaol, 81 were Sunday-school teachers, besides clergymen and their sons, solicitors, schoolmasters by the dozen, commercial travellers, and others. From very recent observation, he found that out of 649 criminals in that gaol 593 had been Sunday scholars, on the average between six and seven years each. This state of things arose from the bad example of parents and companions, and the temptation of drink.

Mr. Busk, Professor McClellan, and Mr. Prideaux also took part in the discussion, which turned much upon the cranial measurements; and it appeared, from the contradictory opinions held by the speakers, that all our collections of crania, their measurement and delineation, have yet led to very little result. We had thought, that however much the details had been disputed, the basis of Phrenology, that the brain is the organ of the mind, and that its anterior portion is the seat of the intellect, was pretty generally admitted. Mr. Busk and Prof. McClellan, however, assured the audience that there was much to be said on the other side, and that they inclined to the belief that the intellectual faculties had their seat in the back

part of the head, and that the broad expansive forehead had nothing whatever to do with the supremacy of human intellect.

Dr. Henry Blanc, Staff Assistant-surgeon, Bengal Army, read a paper "On Human Vaccine Lymph and Heifer Lymph compared." He believed it was an established fact that certain skin diseases and syphilis were transmitted by humanized lymph, and that such humanized lymph in time lost its power as a preventive of small-pox. He supported these positions by copious references to facts and authorities, and proposed vaccination direct from the heifer as the only remedy for these evils. By this alone could they render vaccination efficacious, and restore the usefulness and prestige of Jenner's great remedy.

Other papers were, a "Report on Chloral," by Dr. Richardson; "On the Occasional Definition of the Convolutions of the Brain on the Exterior of the Head," by Dr. T. S. Prideaux; "On the Interpretation of the Limbs and the Lower Jaw," by Professor Cleland; and "On Voltaic Electricity in relation to Physiology," by Mr. Bridgman.

Mr. E. B. Tylor presided over the Ethnological and Anthropological meetings. Sir John Lubbock's paper on "The Primitive Condition of Man; being some Remarks in answer to the Speculations of the Duke of Argyll," attracted a crowded audience. This was an elaborate essay, of which it is impossible to give a brief abstract. Its main object was to show that man had steadily progressed from an early state of moral and mental as well as social barbarism, and that knowledge meant civilization, ignorance barbarism. The Duke of Argyll, on the other hand, had maintained that there was no necessary connection between a state of childhood, as regards knowledge, and a state of barbarism, and that some of the worst savages were the descendants of more civilized races. Sir George Grey was inclined to support Archbishop Whateley and the Duke of Argyll. He had witnessed in London scenes of barbarism such as he had never met with among savage nations. He believed civilization was inseparable from religious feeling, and this did not depend upon material progress. Mr. Howorth gave instances of nations in Eastern Asia which had undoubtedly degenerated. Mr. Wallace admitted that the evidence was overwhelming for a steady advance in knowledge and intellect, but doubted if there was any similar evidence of an equal advance in moral feeling. Savages possessed a moral sense which influenced them just as much as it influenced civilized people. Knowledge and civilization gave to morality a wider sphere of action, but the sense or feeling itself did not appear to be more generally diffused or more active in civilized than in savage man. Dr. Blanc, Sir

Walter James, Messrs. Evans, Boyd Dawkins, and others also took part in the debate.

Dr. P. M. Duncan read a paper "On the Age of the Human Remains in the Cave of Cro-Magnon, in the Valley of the Vezere." In this cave four distinct layers of charcoal or ancient hearths had been found, containing bones of the mammoth and reindeer mixed with human bones; and Dr. Duncan argued that the circumstances were such as to indicate that this case did not prove man to be contemporary with the mammoth, since the bones might have been brought to the cave by hunters at a later period.

Col. Lane Fox then described his discovery of flint implements at Acton and other places in the valley of the Thames, in gravels, a hundred feet above the present river, at which level it had undoubtedly flowed when the gravel was deposited.

A Crannoge or lake-village in South Wales was described in a paper by the Rev. Mr. Dumbleton. It was situated in the Lake of Llangorse, and was very similar in construction to some of the Swiss lake-villages. Some of the piles were exhibited, as well as bones of the horse, ox, sheep, and wild boar, which were found there.

Mr. Lewis read a paper "On the Builders and Purposes of Megalithic Monuments." He said there existed a practically unbroken chain of megalithic monuments extending from India to Great Britain. Who were their builders? Identity of place and other traces of affinity led to the conclusion that there must have been at least a great common influence at work, though possibly not an absolute community of race. He held that they were probably constructed under Celtic influences—that the single upright stones were used as memorial pillars, the circles and alignments primarily as places of sacrifice, and the dolmens or table-stones, of which there were two well-marked varieties, in one view as places of sepulture, and in the other for purposes of sacrifice or memorial.

Many other papers were read before this department, which we have only space to mention. Sir Duncan Gibb had three,—"On the Paucity of Aboriginal Monuments in Canada," which he imputed chiefly to the severity of the climate; "On an Obstacle to Longevity beyond Seventy Years," which he found to be pendency of the epiglottis; and "On a Cause of Diminished Longevity among the Jews," namely, eating too much fat and oil: "On the Primeval Status of Man," by Mr. W. C. Dendy, was a somewhat vague essay on the origin of man, opposing the views of Huxley and Darwin, and leading to a long and rambling discussion; "On the Westerly Drifting of Nomades from the Fifth to the Nineteenth Century," by Mr. H. H. Howarth; "The Origin of the Tasmanians," by Mr. J. Bonwick; "The Natives of Vancouver's

Island and British Columbia," by Dr. King; "On the Esquimaux considered in their relationship to Man's Antiquity," by Capt. W. S. Hall; "On Human Remains in the Gravels of Leicestershire," by Mr. Francis Drake, F.G.S.; "On the Method of forming Flint Flakes by the early Inhabitants of Devonshire," by Mr. F. M. Hall; "On the Frontier Line of Ethnology and Geology," by Mr. H. H. Howarth; "On the Brain of a Negro," by Mr. R. Garner; and "On the Race Elements of the Irish People," by Mr. G. H. Kinahan.

Geography. (Section E.)

Ethnology having this year been transferred to Section D, Section E was devoted exclusively to Geography. The meetings were held in the new Victoria Hall, and were presided over by Sir Bartle Frere, who, as Sir Andrew Waugh said during a discussion on one of the papers, proved his capacity not only to govern a great empire, but also to worthily fill Sir Roderick Murchison's chair. Though the Ethnological papers and discussions did not offer the attractions which had marked the proceedings of previous years, though the veteran President of the Royal Geographical Society was not present to add to its *prestige*, and though there were no Bakers, nor Palgraves, nor Livingstones present to give it additional *éclat*, the Section yet maintained its usual popularity, and was daily attended by a large and attentive audience. Papers were read by both English and foreign geographers, whose renown is more than European; and the discussions were often carried on by men distinguished not less for their statesmanship than for their scientific accomplishments. The papers were generally purely geographical; they were not merely descriptive, but frequently partook of a truly scientific character. Now and then, however, the political element could not be altogether repressed, and on these occasions the discussions turned on questions which are regarded by the general public with more than ordinary interest.

Though Sir Bartle Frere, in his opening address, disclaimed the intention "to attempt any systematic summary of the progress, present state, or prospects of Geographical science generally," he yet showed what was being done by geographers in all parts of the world, but dwelt, as might be expected, more on Asia than on any other continent. After referring with satisfaction to the presence at the meeting of more than one geographer who would represent that vast Russian empire which is gradually extending its borders in Central Asia, Sir Bartle pointed out that this magnificent region is little changed, save in political condition, since it was a nursery of great nations and a centre of civilization. "Here were nurtured,"

he said, "not only kings and founders of empires, but trains of thought and vast systems of moral and political philosophy, which have largely subdued and influenced the richer regions of the South and West. What," he asked, in continuation, "has inflicted on countries once so famous such a curse that the solitary traveller who passes through them, as Vambery did, in disguise, is welcomed among us as one just escaped from almost certain death, who has during his whole sojourn carried his life in his hand?" He then expressed an opinion that nothing but good could result from the attention of English and Russian statesmen being directed to the condition of those countries and peoples which intervene between the boundaries of the two empires. The character of the papers relating to Asia which would be read by Mr. Douglas Forsyth, Mr. Trelawney Saunders, and others, were then explained, and a brief sketch given, with a summary of results, of the various attempts which have been made during the year to explore the central portion of the vast continent under consideration. The whereabouts of Dr. Livingstone was also naturally discussed; but Sir Bartle said that since the last meeting the evidence received has been purely negative; and "we still only know that, up to December, 1867, he was alive and well, and in good spirits, travelling westward from the neighbourhood of Lake Nyassa, and that he disappeared in the obscurity of the regions beyond." Further than this all is conjecture—whether we shall hear of him on the Nile, on the Congo, or at Zanzibar, is at present a pure subject of speculation. Mr. Erskine's explorations on the Lower Limpopo, Mr. Winwood Reade's journey towards the sources of the Niger, Mr. Chandless's explorations on the tributaries of the Amazons, and other interesting subjects were successively referred to; and Sir Bartle concluded his address with the expression of his satisfaction at the presence among them of such eminent foreign geographers as M. Khanikof, M. Pierre de Tchihatchef, and Chevalier Cristoforo Negri, the "Murchison of Italy."

The first paper read in the Section after the President's address on Thursday, was by Dr. R. J. Mann, "On the Position of the Mouth of the Limpopo." In this paper Dr. Mann explained that his friend, Mr. St. Vincent Erskine, the son of the Colonial Secretary of Natal, had settled a point which had long been disputed about by geographers, and by a remarkably adventurous and dangerous journey had shown what really was the outlet of the great African river into the ocean. The mouth of the stream at full tide was found to be 300 yards wide; and a succession of small rollers which broke over the shore indicated a shoal coast. There was a broad lagoon, shut in by a bar of dry sand, except where the river ploughed through it in a comparatively narrow channel. Mr. Erskine took an observation of the altitude of the sun at noon,

and found the position of the mouth of the Limpopo to be 25° 15′ South, but was unable to get the longitude, owing to the difficulties of transit having compelled him to abandon his instrument. The value of a "Small Altazimuth Instrument for the use of Explorers" —a description of which by Colonel Strange concluded the day's proceedings—was here made manifest, as by its means Mr. Erskine would have been enabled to fix his position with the greatest ease and accuracy.

The second paper was by Dr. Beke, and was entitled, "Plan of a Canal to unite the Upper Nile with the Red Sea." The idea conveyed in this paper is not new, a sovereign of Ethiopia having, several centuries ago, threatened to carry out a similar "plan," in order to be revenged on the ruler of Egypt. The notion is that a canal might be formed along a natural watercourse, and that the Atbara—"the black mother of Egypt," as Sir Samuel Baker calls the river—might be diverted to the Red Sea. The Nilotic fertilization being thus turned in another direction, Egypt would speedily become a desert. Sir Bartle Frere thought the paper did not contain such an impracticable suggestion as might at first sight appear; but Dr. Blanc, one of the late captives in Abyssinia, considered the difficulties in the way of the construction and navigation of the canal to be insuperable.

"A Visit to the Holy City of Fas, in Morocco," by Mr. J. Stirling, was next read. The author visited Fas in the suite of Sir J. Drummond Hay, the British Minister, in November last; the party being, it is said, the only Europeans, with the exception of Lord St. Maur, the eldest son of the Duke of Somerset, who have visited the city in modern times. The place once served Moorish pilgrims as a substitute for Mecca, hence probably the term "holy." Fas is fortified, and well situated on a tributary of the river Sebu. The population of the city could not be accurately ascertained, but Mr. Stirling estimated it at somewhat less than 100,000.

Captain T. P. White, R.E., furnished a paper on a "Bifurcating Stream in Perthshire;" and Captain C. Dodd gave some "Notes on a Recent Visit to the Suez Canal."

The second day's proceedings commenced with a description, by the President, of "The Runn of Cutch and the Countries between Rajpootana and Sinde." Sir Bartle had visited this singular tract of country in the exercise of his official duties. It forms a great belt, with neither mountain ranges nor river systems; yet it cannot be called a plain, for it is ridged into sand-hills, nor can it be designated a desert, since it is everywhere inhabited, and in some parts supports a considerable fixed population and numerous herds of cattle. Cutch is a district about 600 miles long, its breadth

varying from 70 to 150 miles. It is divided into two great portions, the southern portion, generally marked as a morass, being the "Runn;" the northern part consisting of sand-hills, which the people consider to have been formed by the wind, but which Sir Bartle Frere considers to have been formed by subterranean forces, by the upheaval of the earth during an earthquake. The people inhabiting this district are much attached to their sand-hills, and possess a lowly kind of civilization. The Runn is not a bog, as seems sometimes to be considered, but a perfectly flat, hard plain, formed of sand and clay, the surface being so hard that the hoofs of a horse galloping over it would scarcely leave their impress behind. If rain falls, it finds no outlet, but remains until evaporated, and becomes salt through the extreme saline nature of the surface. No animals, vegetables, hollows, nothing that might be expected to be seen on any part of the earth's surface, can be found in this curious district. It is also destitute of landmarks, and travellers perform their journeys by night, guiding themselves by the stars, and in one part, by a fire which is lighted and kept burning on a hill by a family residing near the spot. The Runn is subject to periodical inundations by the waters of the Indian Ocean; several rivers also discharge themselves into it on the eastern side, but the water is seldom more than three feet deep. The character of the mirage in this district is extraordinary during the dry season, and the deceptive resemblance to a large and magnificent city with its palaces and towers is often seen. Sir Bartle Frere said he would not pretend to solve the problem how this peculiar table-like district was formed, but would "hazard the conjecture that it was somehow connected with the constant vibration caused by the very active and persistent volcanic action, evidence of which was found in the country around the basin, formed on the one side by the Thurr, and on the south by the semicircular land and Cutch proper. There could be no doubt that volcanic action all around there was more active than in any other part of the world." In attributing the peculiar geological phenomena to volcanic action, Sir Andrew Waugh agreed with the President; but Sir Charles Trevelyan thought with the natives that the sand-hills in the north-western part were more or less connected with the wind.

A paper, entitled "On the Latitude of Samarcand," and read in French by M. Nicholas de Khanikof, followed. M. de Khanikof visited the famous capital of Tamerlane in 1841, being, next to his companion, Lehmann, the first European who had seen it since Gonzales Clavijo, envoy of Henry VIII., of Castile, entered the city in 1404. He was not able himself to fix either the latitude or the longitude of Samarcand, but M. Struve, who was there on a scientific mission last year, has proved the latitude to be 39° 38′ 45″, and the longitude 64° 38′ 12″.

"Central Asia," by M. Pierre de Tchihatchef, Conseiller d'Etat, S.M. l'Empéreur de Russie, attracted much interest and attention. The author first referred to the intended publication of a new, complete, and correct edition of Humboldt's *Asie Centrale.* Such a work would, at present, be peculiarly important and strikingly opportune, for it would dispel for ever the threatening clouds which, during so many years, were gathering on those regions as gloomy forebodings of a dreadful contest. While our knowledge of Central Asia remained scanty and vague, the mysterious country must have appeared, not only to the ignorant crowd, but also to many of the most enlightened and sagacious statesmen, as the natural battle-field where, sooner or later, England and Russia had to meet in a dogged, exterminating struggle. "The danger seemed so unavoidable and so urgent, that no expenses, no sacrifices were spared, in order to postpone the disastrous crisis. Now, thanks to the exertions of geographers, the ominous crisis, so positively prophesied and so unanimously feared, turned out to be nothing more than a fantastical dream; for nothing, surely, could be more fantastic, nothing more fitted to remind one of the *Thousand and One Nights,* than to see a large army with heavy artillery, not only hover like ghosts during two or three months over dense clouds and eternal snows, but even after such an exhausting gymnastic feat, descend into the country of the enemy, and defeat the English troops quietly and comfortably expecting their curious visitors." This, however, is precisely the fact, which must be admitted by the advocates of a Russian invasion of India; for M. de Tchihatchef says we possess numerous trustworthy documents which prove most positively that even in the very probable case of the whole of Turkestan becoming a Russian province—whatever might be the starting-point of the Russian army intended to reach the Punjab—no less than two, or perhaps even three, months would have to be spent amidst snowy, desert mountains, before such an army would be allowed to put its frost-bitten feet on English territory. M. de Tchihatchef admitted that amongst the advocates of Russian invasion there are men of deep science and unquestionable good faith; but they all start from two very arbitrary hypotheses, *viz.* that what has been done once may be performed again, and that what is now impossible may become possible. Alexander the Great and certain Mogul conquerors may have crossed the mountains and marched victoriously onward; but the conditions under which they performed these feats were widely different to those which would be imposed upon an invading Russian army. The Abyssinian expedition brilliantly proved that a European army might drag its ponderous artillery over large, snowy, mountainous tracts; but the result of that expedition might not have been so glorious had the army of resistance been composed of French, Russian, or Prussian soldiers, instead of those of Theo-

dore. M. de Tchihatchef declared the Russian invasion of India to be a bugbear; but intimated that both England and Russia have a peculiar mission in Central Asia, which can only be successfully carried out by a combination of their exertions, and by their placing their moral and material interests under the mighty safeguard of peace, mutual sympathy, religious toleration, and justice.

In the discussion which followed the reading of this remarkable paper, Lord Halifax said it was undeniable that the advance of Russia towards the northern frontier of India caused some uneasiness; but when he was Secretary of State he gave his attention to this important question, and came to the conclusion that the alarms which existed in many minds were utterly unfounded. These alarms, he believed, M. de Tchihatchef's paper would in a great measure dissipate. Lord Houghton was a little more cautious in expressing unqualified satisfaction at the advances of Russia, though he considered the objects of Russia to be similar to what our own have been, *viz.*—"in a certain degree to promote its own power, but in a greater degree to extend civilization."

Mr. Trelawney Saunders considered the question was not a military one, but one of commercial and administrative competition.

A paper "On the Encroachment of the Sea on Exmouth Warren" was next read by Mr. G. Peacock, and was followed by one, entitled "On the Kitai and Kara Kitai," by Dr. G. Oppert. The Kitai Dr. Oppert described as a people who once ruled over Central Asia and China, and who gave their name to Asia. He also said that the famous Prester John was Emperor of this people, who now live in a humble condition in the Russian Government of Derberd, and in the Siberian district of Ili.

The Section did not meet on Saturday in consequence of the excursion to Plymouth; and on Monday the proceedings commenced with a paper by Captain R. C. Mayne, R.N., on "Recent Surveys in the Straits of Magellan." Captain Mayne alluded to the history of the discovery of the Straits, and described their geographical position. He pointed out their use in avoiding the troublesome passage around Cape Horn; and gave some particulars respecting the size and appearance of the Patagonians and Fuegians. The former are not such giants as have been represented, their average height being from 5 feet 10 inches to 5 feet 11 inches, though he measured one man who was 6 feet 10½ inches high.

Admiral Sir Edward Belcher read a paper "On the Distribution of Heat on the Sea Surface throughout the Globe," and was followed by Mr. A. G. Findlay "On the supposed Influence of the Gulf-stream on the Climate of North-Western Europe." The author demurred to many of the theories that have been advanced on this subject, and accounted for the phenomena of our warm winter

climate as follows:—"The great belt of south-west winds called the Anti-trade, or Passage winds, passes over the North Atlantic throughout its breadth, and drives slowly the whole surface of the water to the northward of an easterly course or towards the shore of North-West Europe. From the particular configuration of the land, this north-west drift is allowed to pass into the Polar area. This south-west wind infuses into high latitudes the temperature and moisture of much lower parallels, and by its greater rate of travelling passes over the warmer water to the southward, and this brings to Exeter in one day the warmth of the centre of France. By its variation from westward or eastward of a southerly direction, we find all the variations or moisture which is induced by this wind passing over land or sea."

"On the Best Route to the North Pole," by Captain R. V. Hamilton, R.N., and "The Upper Amazons," by Mr. F. F. Searle, were the concluding papers of the day.

The Section met for the last time on Tuesday morning. "Cooper's Attempt to Cross from China to India" was read by Mr. Trelawney Saunders. Though the details of Mr. Cooper's adventures were very interesting, Mr. Saunders pointed out that he had been unable to contribute anything of value in a geographical point of view, and his enterprise was fruitless and unsuccessful through the jealousy and cupidity of the Chinese mandarins.

A lengthy and important paper on the "Trade Routes between Northern India and Central Asia" was next read by Mr. Douglas Forsyth. This distinguished member of the Indian Civil Service said that he had no geographical discoveries to make known, but he intimated that the work of applying to practical purposes the knowledge acquired by scientific men ought to receive some share of general approval. Having described the two great outlets for trade from Northern India, and given a history and description of the country north of the Himalayas, Mr. Forsyth showed that Central Asian trade is not a myth, as has been asserted, but is very valuable and capable of immense development.

Mr. Trelawney Saunders then read a paper "On the Himalayas and Central Asia," and explained that the difficulties in passing the mountains are not insurmountable to trade and intercourse. The vast countries beyond the Himalayas constitute the greatest pastoral region in the world; and as there is such a field of raw material, there would doubtless be found an equally important market for manufactured articles. In the discussion which followed the reading of these three papers, Sir Harry Verney, Sir Stafford Northcote, Dr. Thomson, and the President took part. Sir Harry Verney said our duty is to give every facility for the opening up of trading intercourse with Central Asia, but we should

not endeavour to obtain any monopoly, and should speak in unmistakable language to prevent the distrust of any other power. Sir Stafford Northcote deprecated the idea that our duties to commerce and civilization should be regarded in the nature of rivalry with Russia. We must consider the question as bearing on the interests of the great masses of people committed to our charge in India, and consider also that whatever is for the advantage of India must be for the advantage of adjacent peoples. We must be careful not to engage in any enterprises likely to bring us into collision with the frontier tribes, and must not put our arm out farther than we could draw it back again. Sir Stafford declared it to be for our interest, as far as possible, to surround our empire in India with independent, flourishing States, which would feel it to be their interest to be on good relations with us, and that their prosperity was bound up with ours.

A "Scheme for a Scientific Exploration of Australia," by Dr. G. Neumayer; a paper by Mr. W. P. Blanford "On Northern Abyssinia;" and one "On Raleigh's El Dorado," by Dr. C. Le Neve Foster, concluded a by no means unimportant or uninteresting, if not a brilliant, meeting.

Mechanical Science. (Section G.)

This Section met in St. John's Hospital, under the Presidency of Mr. C. W. Siemens, C.E., F.R.S., by whom a very excellent and instructive opening address was delivered. Including the Presidential address, the reports from committees, and papers from members, there were altogether twenty-five communications made to the Section, if we likewise include four papers which were taken as read at the last sitting of the Section. As Saturday was set apart for the excursion to Plymouth and Devonport, and as the subject of the Patent Laws naturally attracted the engineers to the Statistical Section on the ensuing Wednesday, the last day of the Exeter meeting, Section G had only four sittings—on Thursday, Friday, Monday, and Tuesday.

The President's address embraced some remarks on the somewhat hackneyed subject of technical education, and specially commended Mr. John Scott Russell's lately published volume treating on this subject. Almost as a matter of course, Mr. Siemens dwelt at some length on the system of Letters Patent, on which he can certainly speak as "one having authority." He put the question of the theory and practice of Letters Patent in a very clear light by the following brief statement. "According to modern views," he said, "a patent is a contract between the Commonwealth and an individual who has discovered a method, peculiar to himself, of accom-

plishing a result of general utility. The State, being interested to secure the information, and to induce the inventor to put his invention into practice, grants him the exclusive right of practising it, or of authorizing others to do so, for a limited number of years, in consideration of his making a full and sufficient description of the same. Unfortunately, this simple and equitable theory of the patent system is very imperfectly carried out, and is beset with various objectionable practices which render a patent sometimes an impediment to, rather than a furtherance of, applied science, and sometimes involve the author of an invention in endless legal contentions and disaster, instead of procuring for him the intended reward. These evils are so great and palpable that many persons, including men of undoubted sincerity and sound judgment on most subjects, advocate the entire abolition of the patent laws. They argue that the desire to publish the results of our mental labour suffices to ensure to the Commonwealth the possession of all new discoveries or inventions, and that justice might be done to meritorious inventors by giving them national rewards. This argument may hold good as regards a scientific discovery, where the labour bestowed is purely mental, and carries with it the pleasurable excitement peculiar to the exercise and advancement of science on the part of the devotee; but a practical invention has to be regarded as the result of a first conception, elaborated by experiments and their application to existing processes in the face of practical difficulties, of prejudice, and of various discouragements, involving, also, great expenditure of time and money, which no man can well afford to give away, nor can men of merit be expected to advocate their cause before the national tribunal of rewards, where, at best, only very narrow and imperfect views of the ultimate importance of a new invention would be taken, not to speak of the favouritism to which the doors would be thrown open. Practical men would undoubtedly prefer either to exercise their inventions in secret, where that is possible, or to desist from following up their ideas to the point of their practical realization."

Mr. Siemens also referred to Watt's invention, patented 100 years ago; to recent progress and prospective efforts in railway and telegraphic engineering; to the engineering progress in respect of offensive and defensive warfare; to the newest methods of making steel for constructive purposes; to Mr. Whitworth's experiments, the results of which seem likely to render the steam-hammer and rolling-mills obsolete in the process of forging steel; to scientific economy in generating heat from coal; and to the production of refrigeration at an extremely moderate expenditure of fuel and labour. On the motion of Mr. Bidder, a hearty vote of thanks was awarded to Mr. Siemens for his interesting, instructive, and very appropriate address.

At the first day's sitting there were read papers by Mr. Fairbairn, Col. H. Clerk, R.A., and Mr. R. Eaton. Mr. Fairbairn's was a "Further Report on the Mechanical Properties of Steel." It was very elaborate and highly statistical. A point of considerable importance in connection with the communication was the reliable details given regarding the properties of the Heaton steel. Mr. Fairbairn's experiments referred almost exclusively to the Heaton steel, and to the Barrow Company's hæmatite steel. The last-mentioned substance has very great "ductility combined with a tensile breaking-strain of from 32 to 40 tons per square inch. With these qualities," said Mr. Fairbairn, "I am informed that the proprietors are able to meet the requirements of a demand to the extent of 1000 to 1200 tons of steel per week, which, added to a weekly produce of 4500 tons of pig-iron, enables us to form some idea of the extent of a manufacture destined in all probability to become one of the most important and one of the largest in Great Britain."

The paper by Colonel Clerk, entitled "Description of the Hydraulic Buffers and Experiments on the Flow of Liquids through Small Orifices at High Velocities," gave rise to a very interesting discussion. The author of the paper being desirous of applying some method of checking the recoil of heavy guns, consulted Mr. Siemens about two years ago, and suggested magnetism as the form of force to be employed; but the "magnetic doctor," as Mr. Siemens has been styled, suggested hydropathic treatment rather than magnetic, and in Col. Clerk's hands it has proved to be most valuable, so valuable, indeed, that the hydraulic compressor or buffer invented by Col. Clerk is now being tried in a modified form by railway engineers. The buffer has been used on shore with guns up to 25 tons weight, and at sea with light guns of 1½ cwt. and 8 cwt. in boats, and with 9-inch guns of 12 tons on board H.M.S. 'Prince Albert,' and in all cases with great success.

Mr. Eaton's paper was "On Certain Economical Improvements in obtaining Motive Power." It contained an account of a modification of the steam-engine recently made and brought into use in Nottingham by Mr. George Warsop, the son of an air-gun maker, born with aërial ideas, educated at a Sunday-school, and sent to work at ten years of age. Later in life he was a working mechanic in the employment of Ericsson, in New York, and had an opportunity of noting the weak points of that eminent engineer's air-engines, and profited by the experience gained. More recently Mr. Warsop has devised, in the words of Mr. Eaton, "a marvellously simple system of mechanism, which, as far as present experience goes, promises complete success by means which, happily for the cause of economy and progress, are compatible alike with physical science

and mechanical construction." The piece of mechanism is known as the Aëro-Steam Engine, and, as may be inferred from the name, the motive-power is a mixture of air and steam. Before a very decided opinion can be given regarding this invention, it will be requisite to wait for the results of the experiments which are in progress, or in prospect, by Professor Tyndall and others.

Professor W. J. M. Rankine, C.E., F.R.S., read two reports from committees of which he is a member. One was "On the Laws governing the Flow and Action of Water containing Solid Matter in Suspension," and the other was an "Interim Report from the Committee on Agricultural Machinery." It was stated that a full and satisfactory report on agricultural machinery would be ready for next year's meeting.

"On the Laws determining the Fracture of Materials when Sudden Changes of Thickness take place," formed the subject of a somewhat technical paper by Mr. F. J. Bramwell, C.E.; and Admiral Sir Edward Belcher communicated a paper "On a Navigable Floating Dock;" but the chief point of interest at Friday's sitting of the Section was the very elaborate paper "On the Channel Railway," giving an account of the method by which Mr. J. F. Bateman, C.E., and M. Rèvy, C.E., Vienna, propose to connect England and France. The paper was too long for us to make anything like an intelligible abstract of it. Suffice it to say that Messrs. Bateman and Rèvy's scheme embraces a cast-iron tube, thirteen feet in internal diameter and four inches thick, with additional strengthening in the way of ribs, flanges, and annular discs or diaphragms, and that railway trains are to be worked through this tube by pneumatic pressure. In an animated discussion which followed the reading of the paper, Messrs. Bidder (father and son), Vignoles, the President, and other gentlemen took part.

At Monday's sitting no fewer than four reports were read from committees, the reporters being Mr. L. E. Fletcher, C.E.; Mr. C. W. Merrifield, F.R.S.; Professor Rankine, and Mr. R. B. Grantham, C.E.; and the reports being, respectively: on Boiler Explosions; on the State of Knowledge of Stability and Sea-going Qualities of Ships; on the Analysis and Reduction of Observations in the Report of the Steamship Performance Committee, and on Sewage. The following are the conclusions arrived at by the Boiler Explosion Committee:—1. That a lamentable loss of life is annually caused by steam-boiler explosions, which urgently calls for public attention. 2. That these explosions, as a rule, are not accidental, but may be prevented by the exercise of "common knowledge and common care." 3. That the present investigations conducted by Coroners with regard to steam-boiler explosions are eminently unsatisfactory, and call for immediate improvement. 4. That Coroners

should, when conducting inquiries on boiler explosions, be instructed and empowered to avail themselves of competent engineering advice, so that the cause of every explosion may be fully investigated, while the information acquired should be widely circulated. 5. The committee entertain a sanguine hope that this course alone would do much towards the prevention of the present recurrence of steam-boiler explosions, without any further governmental action. The report was signed by Mr. Fairbairn, the Chairman of the committee. By way of supplement to the report, and for the purpose of raising a discussion, Mr. Fletcher submitted a short paper "On Government Action with regard to Boiler Explosions." The discussion took place on the following day, and it may be referred to at this stage. Mr. Alcock, Mr. Bramwell, Mr. Longridge, Captain Galton, Mr. Webster, Q.C., Professor Rankine, the President, and others took part in it, and all deprecated Government interference in the way of inspection. Various suggestions were made in reference to the stamping of boiler-plates by the makers; to the persons employed as boiler-tenters; to the qualifications of boiler-makers; and in reference to the way in which boiler inspection should be conducted. It was strongly urged by several of the speakers that efforts should be made to strengthen the hands of the Coroner, and render his court of inquiry a reality instead of a sham, and that persons using steam-boilers should be made responsible for the consequences caused by explosions. In the course of the discussion Captain Galton stated that he had induced the Government to place some hundreds of boilers under the inspection of the Association for Guaranteeing Steam-boilers against Explosion.

The report submitted by the Steamship Performance Committee was a very full and valuable paper, but notwithstanding its fulness it only claimed to be a *first* report, treating of only a portion of the subject, namely, the resistance which ships offer to propulsion, and to their behaviour in respect of rolling. The value of the report "On the Treatment and Utilization of Sewage" can scarcely be overrated. It had previously been submitted to the Chemical Section by Dr. B. H. Paul, who compiled it. Its value did not depend upon the opinions expressed by the Committee, inasmuch as they did not express any, but upon the facts which it brought together regarding the efforts at treatment and utilization of sewage both at home and abroad. Through the Home Office the Committee obtained information from Hamburg, Saxe-Coburg Gotha, Holland, Bavaria, Baden, Saxony, Prussia, Switzerland, Austria and Hungary, Belgium, Sweden, Denmark, Turkey, Greece, Russia, the United States of America, and Wurtemburg; and by means of schedules sent out to 338 local, sanitary, and sewer authorities, the committee obtained replies from 107 places to the queries contained in the schedules. Those queries referred to the population,

area, number of houses, and rateable value of the places applied to; the nature, source, and extent of the water-supply; the disposal of the excretal refuse; and to the total quantity and amount of the liquid sewage and its treatment. The committee is re-appointed, and therefore we may expect that next year's report will prove a valuable supplement to the one read at Exeter.

Some interesting facts were mentioned by Mr. Thomas C.E., in his paper "On Roads and Railways in Northern India, as affected by the abrading and transporting power of Water." This paper was followed by one of great value from Mr. Joseph Whitworth, C.E., F.R.S. It was "On the Penetration of Armour-Plates with Long Shells having Large Bursting Charges, and fired obliquely," and was a sort of supplement to the paper read by Mr. Whitworth at the Norwich meeting last year. The author claimed that the experiments detailed in his paper showed that the Palliser projectiles failed to penetrate when striking at an angle, solely on account of the form of the head,—the Whitworth projectile, which resisted the shock, and did not break up, being deflected in precisely the same manner as the Palliser projectile which was shivered into fragments. Almost all the speakers who joined in the discussion excited by the paper, spoke very favourably of the flat-headed projectile, and urged that trials should be instituted with it by the Government.

Of the papers read at the last sitting of the Section, that by Mr. Thomas D. Barry "On the Utilization of Town Sewage" produced the greatest amount of discussion. It was not much else than a glorification of the A B C process as practised at Leamington. Neither the paper nor the resulting discussion did much good in the way of throwing light on this vexed question.

A rather abstruse paper by Mr. Latimer Clark "On the Birmingham Wire Gauge" was read in the absence of the author. One by Mr. S. A. Varley was of much more general interest: it was "On a New System of Communication between Guards and Passengers on Railways." Mr. Varley's system is one of great ingenuity and is thoroughly efficient. At the request of the Board of Trade it was fitted up in a train running daily from London to Wolverhampton—a distance of 250 miles. The train was started from all stations at which it stopped by means of the apparatus, and its working reported by the guards in their daily reports. The apparatus was tested twenty-two times, and its performance, as shown by those reports, was marked by the most unvarying regularity. It is desirable to mention that Mr. Varley's system is an electrical one, but it does not require any electrical knowledge in the person working it. In closing the discussion upon the paper, the

President remarked that his own idea was that the electrical system was the only one which would work satisfactorily.

Mr. E. Froude read a paper, in which he detailed some curious and successful efforts to clean the internal surface of the Torquay water-main, an iron pipe fourteen miles long. In the year 1864 the delivery of water from the main was reduced to 320 gallons per minute, or only about one-half the amount due to the size and fall of the pipe. After trying several expedients for scraping off the oxidized material in the pipe by hydraulic pressure, Mr. Froude was able, in April of this year, to increase the discharge to 660 gallons per minute. To keep the pipe in a satisfactory condition it is necessary to scrape it at least once a-year. The cost of scraping is very trifling, and the whole fourteen miles can be done at one time.

In concluding this brief notice of the proceedings in the Mechanical Section, we are bound to admit that a fair amount of interesting work was done; but when we have said this we have almost said all. Of this we feel assured, that the British Association Meeting of 1869 will not be marked in the calendar with a "red letter" in so far as mechanical science is concerned. The meeting of 1870 in Liverpool ought to bring forth something that will be much more worthy of being put on record.

Quarterly List of Publications received for Review.

1. The Scenery of England and Wales; its Character and Origin: being an attempt to trace the Nature of the Geological Causes, especially Denudation, by which the Physical Features of the Country have been produced. *With* 86 *Woodcuts.* By D. Mackintosh, F.G.S. *Longmans.*
2. Wrought-Iron Bridges and Roofs. By W. Cawthorne Unwin, B.Sc., &c. *E. & F. N. Spon.*
3. Entozoa: being a Supplement to the Introduction to the Study of Helminthology. By T. S. Cobbold, M.D., F.R.S. *Groombridge & Sons.*
4. Sound: a Course of Eight Lectures delivered at the Royal Institution of Great Britain. By John Tyndall, LL.D., F.R.S. Second Edition. *Longmans.*
5. The Substitution of Similars: the True Principle of Reasoning. By W. Stanley Jevons, M.A., London. *Macmillan & Co.*
6. The Transactions of the Woolhope Naturalists' Field Club. *Illustrated with Photographs, Lithographs, and Woodcuts.* *Times Office, Hereford.*
7. The True Theory of the Earth. By Research. *Bell & Bradfute.*
8. The Birds of Sherwood Forest. By W. J. Sterland. *L. Reeve & Co.*
9. The Geometry of the Circle and Mathematics. By James Smith. *Simpkin, Marshall, & Co.*
10. Latitude and Declination Tables. By Major-Gen. R. Shortrede. *Strahan & Co.*
11. Abolition of Patents: Recent Discussions in the United Kingdom and on the Continent. *Longmans.*
12. Practice with Science. Vol. II. A Series of Agricultural Papers. *Longmans.*
13. How to keep the Clock Right, by Observations of the Fixed Stars with a small fixed Telescope. By T. Warner. *Williams & Norgate.*

PAMPHLETS AND PERIODICALS.

The Economic Geology of Devonshire and Cornwall in 1868. By R. Hunt, F.R.S. *Clowes & Sons.*

On Geological Dynamics. By Sir William Thomson, LL.D., F.R.S.

On some Fossils found in the Eophyton Sandstone at Lugnas in Sweden. By J. G. O. Linnarsson.

Figures of Characteristic British Fossils. By W. H. Baily. *Van Voorst.*

Notes on the Flora of Manbhúm. By V. Ball, B.A.

On the Copper Mines of Singhbhúm.—(Geological Survey of India.) Same Author.

On Hydrofluoric Acid. By G. Gore, F.R.S.

Öfversigt af Kongl: Vetenskaps-Akademiens Förhandlingar. *Stockholm: P. A. Norstedt & Söner.*

The Thames Gold Fields, Province of Auckland.—(Geological Survey of New Zealand.)

Smithsonian Miscellaneous Collections—

Land and Fresh-water Shells of North America. By W. G. Binney and T. Bland.

Ditto ditto Catalogue of the Orthoptera of North America. By S. H. Scudder.

Report of the National Academy of Sciences.—(Smithsonian Report.)

Observations on the Genus Unio. By Isaac Lea, LL.D., Philadelphia.

Descriptions of Twelve New Species of Unionidæ, &c. Same Author.

Memoirs of the Peabody Academy of Science.

Revision of the large Stylated Fossorial Crickets. By S. H. Scudder. *Salem, Mass.*

Description of a New Instantaneous Wet Collodion Process, &c. By Thomas Sutton, B.A. *J. W. Green, Paternoster Row.*

Colorado (U.S.A.): its History, Geography, and Mining. By R. Old. *London: Brit. and Colorado Mining Bureau.*

A Guide to the Study of Insects. By A. S. Packard, jun., M D. *Salem: Essex Institute.*

Arithmetical Exercises for Chemical Students. By C. J. Woodward, B.Sc.

Ira Connell, or the Evils of Vaccination. *London: F. Pitman.*

Despotism. *Longmans.*

Quarterly Notes on Books. *Longmans.*

The Dietetic Reformer and Vegetarian Messenger. *Pitman.*

Revue Bibliographique Universelle. ***Paris.***
The American Naturalist.
Van Nostrand's Engineering.
The Chicago Medical Times.
The Westminster.
The Geological Magazine.
Scientific Opinion.
The Popular Science Review.
Cosmos. Edited by Victor Meunier. ***Paris.***

PROCEEDINGS OF LEARNED SOCIETIES, &c.

The Journal of the Ethnological Society. *Trübner & Co.*
Proceedings of the Cotteswold Naturalists' Field Club for 1868.
First Annual Report of the Bournemouth Meteorological Society.
First Annual Report of the Trustees of the Peabody Academy of Science. *Salem, Mass.*
Proceedings of the Royal Institution.
" " Royal Society.
" " Royal Astronomical Society.

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